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DELETERIOUS EFFECT OF MIL-F-14256, TYPE RA FLUXES ON PRINTED WI--ETC(U)
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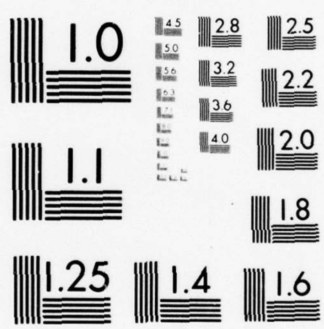

MICROCOPY RESOLUTION TEST CHART
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TR 2253
31 JANUARY 1979

LEVEL II

NAC publication

DELETERIOUS EFFECT OF MIL-F-14256, TYPE RA FLUXES ON PRINTED WIRING BOARDS

See 1473 in back.

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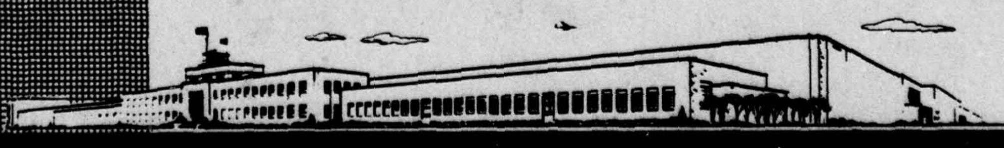

NAVAL AVIONICS CENTER

INDIANAPOLIS, INDIANA 46218

NOTICE

12

NAC TR-2253

PREFACE

This report covers the work performed by NAC's Materials Laboratory from 1 January 1978 to 1 January 1979 on the deleterious effect of MIL-F-14256, Type RA Fluxes on printed wiring boards.

This work was performed for RADC, under sponsorship of Mr. John McCormick, Rome Air Development Center's Reliability Laboratory, Griffiss Air Force Base, NY; FQ761970032 BCN 90474.

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ABSTRACT

This study identified the corrosive effects of Type RA fluxes and flux residues on printed wiring boards subjected to electrical stress in a humid environment at elevated temperature. The effect of varying delay times between soldering and cleaning of flux residues was also studied and the protective value of solder resist and conformal coating was evaluated.

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I. CONCLUSIONS

1. Type RA fluxes have a degrading effect on the insulation resistance of printed wiring boards.

2. The analysis of variance of resistance values for A, B, & C fluxes showed a significant difference in resistance values for the three delay times chosen. Delay in flux residue removal affects degradation.

3. The analysis of variance of resistance values for A, B, & C fluxes showed a significant difference in the amount of degradation caused by each flux. The activity of the Type RA fluxes in this experiment cannot be based solely on water extract resistivity tests specified in MIL-F-14256D.

4. MIL-P-28809 is an excellent tool for the application intended: i.e., determining the level of ionic contamination on a printed wiring board. However, it appeared that one flux left some residue which was not measurable with MIL-P-28809, yet still caused degradation.

5. The analysis of variance of resistance values for A, B, & C fluxes showed a significant difference in the resistance values between the solder mask coated and the conformally coated specimens. The solder mask gave greater protection against degradation than did the conformal coating.

II. RECOMMENDATIONS

1. RA fluxes should be used with caution.

2. RA fluxes should be cleaned immediately from printed wiring boards after soldering.

3. Care should be taken when changing to a different flux. The new flux may not be compatible with the base laminate material.

4. Thorough cleaning of RA fluxes from printed wiring boards is a necessity. However, at present there is no method of detecting non-ionic contaminants. Work should be performed in this area of cleanliness testing.

5. Work should be performed on MIL-F-14256 to determine what additional requirements are necessary for specifying a RA flux; e.g., pH, organics, etc.

III. DISCUSSION

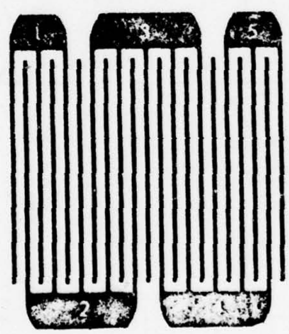
Activated rosin base (RA) fluxes have been generally considered too corrosive for use in the manufacture of military electronic assemblies. However, it is now possible for these fluxes to be used under military specification control. Flux vendors have proposed that once their RA flux has seen soldering temperature and has done its job its residues are rendered inactive. So the question arose: is the insulation resistance of printed wiring boards degraded by such fluxes as they might be generally used in electronics manufacturing?

Rome Air Development Center requested that NAC evaluate the effects of RA fluxes on printed wiring boards.

A literature survey was conducted before this experiment was started. However, it yielded no information about the type of experiment that was performed.

The fluxes used in this experiment were advertised by their manufactures to meet the minimum requirements of MIL-F-14256D, Amendment 1 for RA type fluxes. Three fluxes for testing were chosen on this basis and were designated "A", "B", and "C". Further characterization is shown in Table I.

The comb pattern shown in Figure 1 (below) was used as the basic resistance specimen. It was produced using conventional printed wiring board manufacturing techniques. Historically, a comb pattern specimen has been associated with printed wiring board insulation resistance measurements. This particular pattern is a duplicate of the one used in the IPC Round Robin on the "Additive Process for Producing Printed Wiring Boards". (Dimensions on Dwg. AV22107 in the Appendix.)



COMB
PATTERN

Figure 1.

A total of 200 comb pattern specimens was produced. Approximately 48 specimens were used for each test run.

Using resistance squares, 1.5 x 10^8 ohms insulation resistance on the comb pattern was found to be equivalent to 500 megohms on the trumpet pattern in MIL-P-55110C (equilibration calculation shown on page A-17 in the Appendix). Any resistance value below 1.5 x 10^8 ohms was considered a failure.

TABLE I.

CHARACTERIZATION OF FLUXES

FLUX	WATER EXTRACT RESISTIVITY OHM-CM X 10^3	SOLIDS CONTENT BY WEIGHT	pH 0.1 ml OF FLUX DILUTED WITH 50 ml OF H_2O	CHLORIDE ION INDICATION	WATER SOLUBILITY 0.1 ml OF FLUX IN 50 ml OF H_2O
"A"	69.333	38.2%	4.4	Negative	Soluble
"B"	43.500	34.8%	5.1	Positive	Insoluble
"C"	37.400	35.2%	5.9	Negative	Insoluble
MIL-F-14256D Amendment 1 RA (Rosin Activated) Flux	50.0 Minimum	15% Minimum	No Requirement	No Requirement	No Requirement

TABLE II.

EXPERIMENT MATRIX
RESISTANCE READINGS DURING HUMIDITY & ELEVATED TEMPERATURE STRESSING
MIL-STD-810C, METHOD 507.1, PROCEDURE I.

SPECIMENS PER SET	A[1] 0[2] C[3] 4	A100C 4	AOS 4	A100S 4	$R < 1.5 \times 10^8 \Omega$ DURING TESTING	BOC 4	B100C 4	BOC 4	B100S 4	$R < 1.5 \times 10^8 \Omega$ DURING TESTING	COC 4	C100C 4	COS 4	C100S 4	$R < 1.5 \times 10^8 \Omega$ DURING TESTING
DAYS	72 HOUR DELAY BEFORE FLUX REMOVAL														
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
DAYS	168 HOUR DELAY BEFORE FLUX REMOVAL														
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															
DAYS	IN PLANT, 1 MINUTE DELAY BEFORE FLUX REMOVAL														
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															

1 First letter (A,B,or C) indicates flux used.
2 Number will either be 0(no DC voltage) or 100(DC volts).
3 Last letter indicates conformal coated(C) or solder mask(S).

The experiment was designed so that some test specimens within a test set were very clean when they were ready for temperature and humidity stress. These specimens were used to determine if the copper clad laminate from which all the comb pattern specimens were produced contained any electrical anomalies.

The "Experiment Matrix", Table II, is a visual description of how the experiment was designed. Those specimens within a test set were divided into lots which were then contaminated with the three fluxes. Some test specimens within a flux lot were stressed with 100 volts D.C., while other test specimens were not voltage stressed. Some test specimens within a flux lot were solder mask coated, while others were conformally coated. The test specimens which were tested for electrical anomalies were neither voltage stressed nor coated. Within each flux lot, there were enough specimens provided to permit the data obtained to be analyzed statistically.

For the three fluxes used, there was a total of 48 test specimens for each delay time. This gave a possibility of five control specimens since the maximum which could be loaded into the humidity chamber was 53 specimens.

The MIL-P-28809 Ionic Contaminants Test was used on a sampling basis to monitor boards from the same process lot for cleanliness. (These sampled boards were not temperature and humidity stressed.)

Time between flux fusing and cleaning was the variable chosen to differentiate between temperature and humidity stress runs. It had been proposed that type RA fluxes would attack the insulating base laminate of a printed wiring board. The three

delay times between flux fusing and cleaning were chosed to simulate actual fabrication cycles with 1) in-line cleaning- or 2) 72 hours standing over a weekend, or 3) 168 hours for boards touched up or otherwise held in process for one week.

The temperature and humidity stress conditions of MIL-STD-810C environmental test methods, Method 507.1, Procedure I, were used. This was done because solder flux is used to fabricate printed wiring board assemblies used in electronic equipment. Ultimately the printed wiring board assemblies survive or fail in the environment the equipment sees.

The resistances of the specimens were measured in the humidity chamber during the high temperature and high humidity portion of the temperature and humidity stress cycle. The resistances were measured on 24 hour cycles on working days. The resistance measurements were made using a megohm bridge.

The experiment proceeded with the different delay times in this order:

1. 72 hours delay
2. 168 hours delay
3. In plant, wave soldered and cleaned, 1 minute delay before flux removal

An additional study was made to explore exposure to RA fluxes beyond the ten day requirement of the MIL Standard method. Specimens were prepared by the procedure employed in the main study, except that 1) flux or flux residues were not removed by the previously described cleaning steps, and 2) the MIL-STD-810, Environmental Test Methods, Method 507.1, Procedure I, was run for twenty days rather than ten days.

Some of the findings were:

1. It's possible to meet the humidity and insulation

resistance requirements of MIL-STD-810, Environmental Test Methods, Method 507.1, Procedure I, and at the same time attack the epoxy butter coat of the laminate.

2. Fluxes which appear to be more prone to humidity and insulation failure ($R < 1.5 \times 10^8$ ohms) than some other RA fluxes were very gentle to the epoxy butter coat of glass epoxy laminates.

3. The photographs in the Appendix are typical of what was observed.

NOTE: These are preliminary findings. It is thought they are worthy of mention, but more investigation is indicated. None of the conclusions or recommendations are affected by these findings.

IV. PROCEDURE

1. Make 200 comb pattern printed wiring boards of FL-GF, .062 C 1/1 glass epoxy laminate to conform to Dwg. AV 22109 on page A-24 in the Appendix.

2. Mask the laminate, using dry film resist so that the conductor pattern and the back of the printed wiring board can be plated.

3. Tin/lead plate.

4. Strip resist.

5. Etch unplated copper.

6. Rinse thoroughly in tap water and blow dry.

7. Omit solder fusing operation. (This makes sure that fusing fluid residues do not affect the test results.)

8. Figure 2 shows how the solder mask coated specimen was constructed. Solder mask was applied to the comb specimen which was governed by conductor pads 1, 2 and ½ of 3. Electrical leads were soldered to conductor pads 1 and 2.

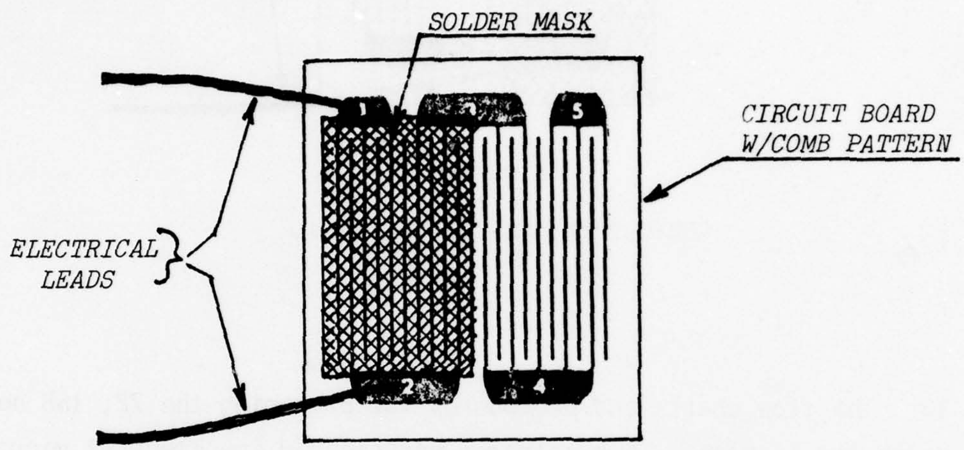


Figure 2.

SOLDER MASK COATED SPECIMEN

9. Figure 3 shows how the conformally coated specimen was constructed. Electrical leads were soldered to conductor pads 1 and 2. The leads exited the specimen from the end opposite conductor pads 1 and 2. This allows the comb specimen governed by conductor pad 1, 2 and ½ of 3 to be conformally coated by dipping.

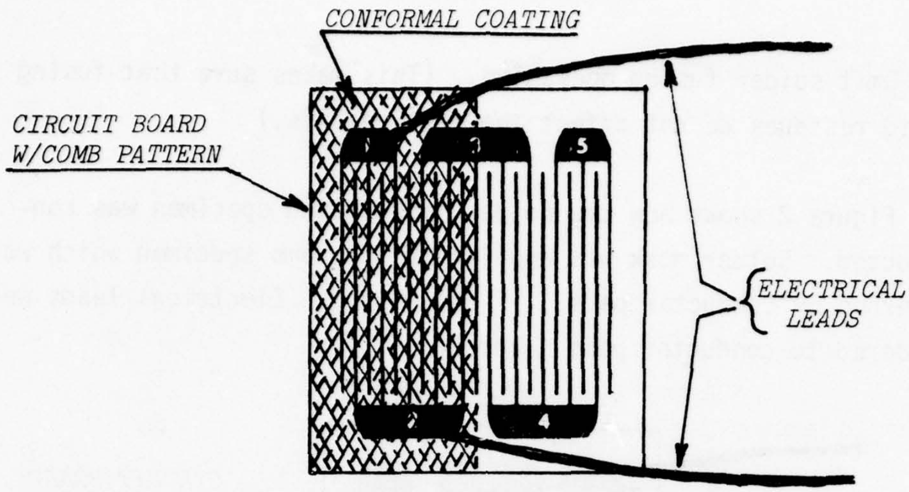


Figure 3.

CONFORMALLY COATED SPECIMEN

10. The flow charts and procedures for producing the 72, 168 hour delay and in-plant, wave soldered and cleaned specimens, 1 minute delay before flux removal, are on pages 12 and 13.

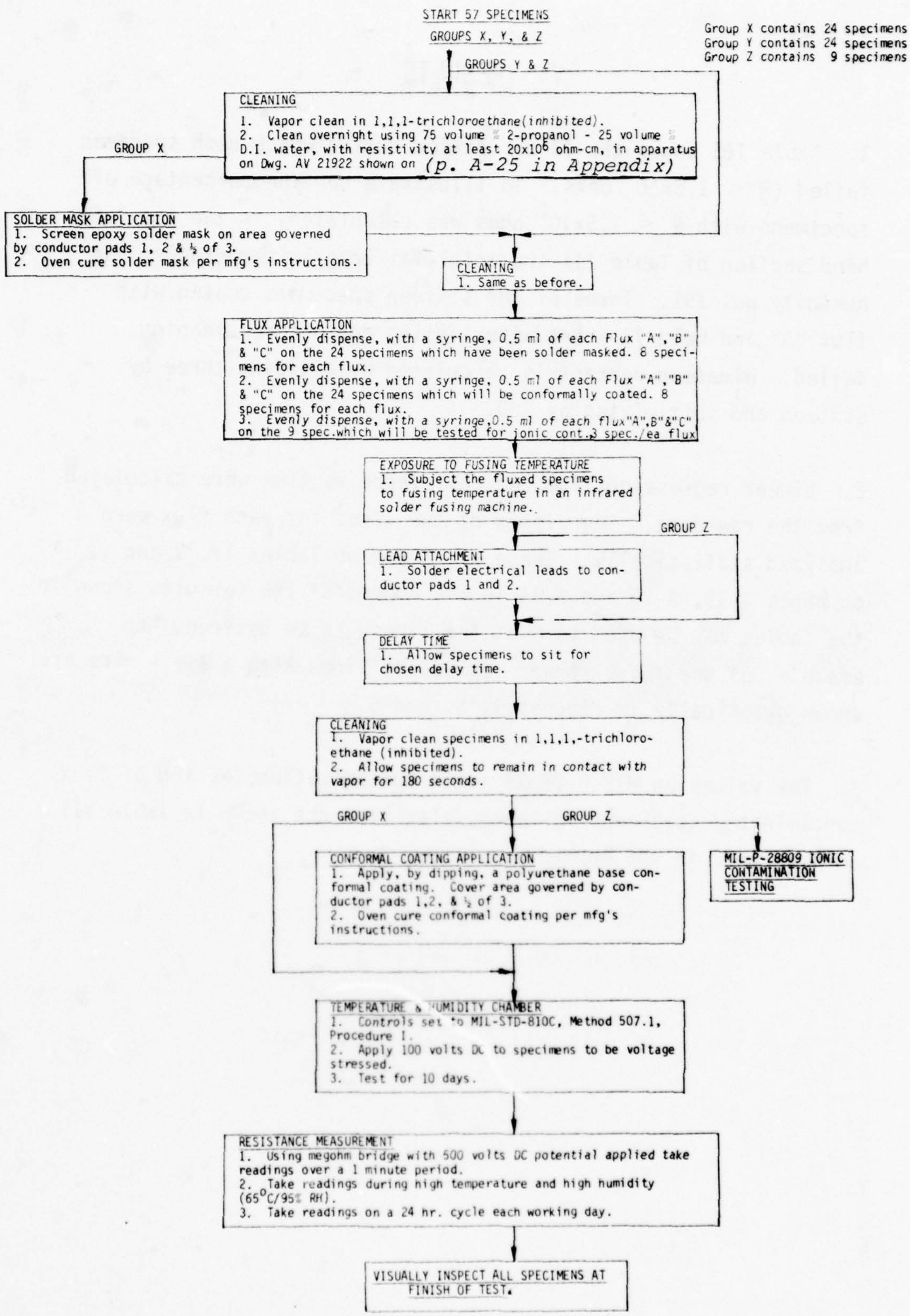
V. RESULTS

1. Table III shows the 24 hr. period during which each specimen failed ($R < 1.5 \times 10^8$ ohms. To illustrate how the percentage of specimens with $R < 1.5 \times 10^8$ ohms was calculated, in the top left hand section of Table III the total failures in temperature and humidity was 19%. Three of the sixteen specimens coated with flux "A" and held 72 hours after fusing and before cleaning failed. Nineteen percent is calculated by dividing three by sixteen and multiplying by 100.

2. Linear regression lines of resistance vs time were calculated from the raw data. The slopes of the lines for each flux were analyzed statistically. These are shown on Tables IV, V and VI on pages A-19, A-20 and A-21 in the Appendix. The formulas shown in the tables may be used to plot the lines, if so desired. An example of the above linear regression lines with $\pm$ 3Sy limits are shown graphically in Figures 4, 5, and 6.

3. The values on MIL-P-28809 ionic contamination testing of flux contaminated specimens for each delay time are shown in Table VII on page A-22 in the Appendix.

FLOW CHART FOR 72 AND 168 HOUR DELAY SPECIMENS



FLOW CHART FOR IN PLANT, WAVE SOLDERED AND CLEANED SPECIMENS

(APPROXIMATELY 1 MINUTE DELAY)

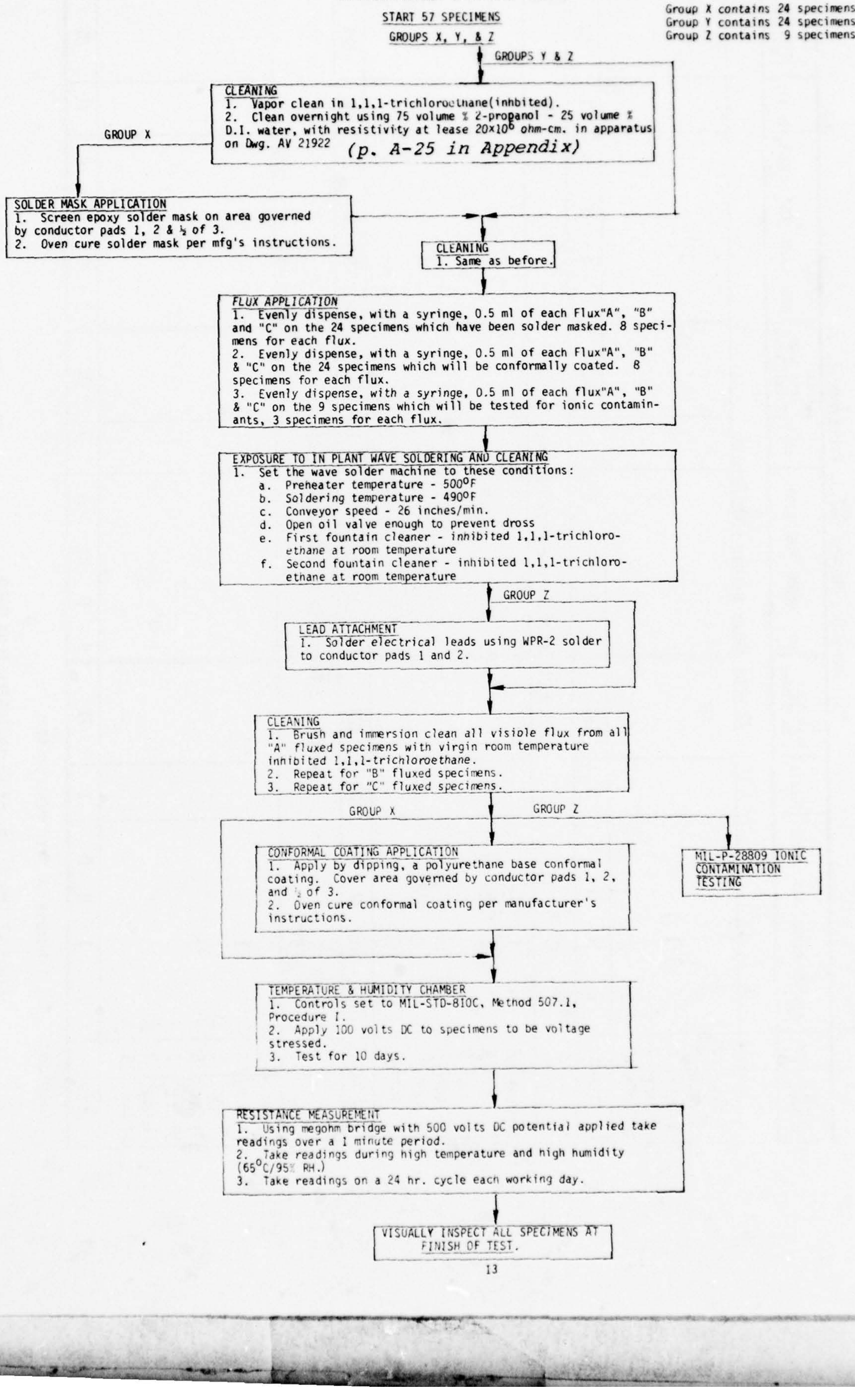


TABLE III.

HUMIDITY & ELEVATED TEMPERATURE RESISTANCES LESS THAN 1.5×10^8 OHMS

MIL-STD-810C, METHOD 507.1, PROCEDURE 1.

DATE (1978)	DAY	A[1]0[2]C[3]	A100C	AOS	A100S	Totals	R is less than 1.5×10^8 ohms	BOC	B100C	BOS	B100S	Totals	R is less than 1.5×10^8 ohms	COC	C100C	COS	C100S	Totals	R is less than 1.5×10^8 ohms
		72 HOUR DELAY BEFORE FLUX REMOVAL																	
3 JULY	3							1											
5 JULY	5	1													1				
6 JULY	6		1																
7 JULY	7																		
10 JULY	10	1																	
TOTALS		2	1	0	0	3	19%	1	0	0	0	1	6%	0	1	0	0	1	6%
		168 HOUR DELAY BEFORE FLUX REMOVAL																	
17 JULY	3								1										
18 JULY	4		1																
19 JULY	5	1																	
20 JULY	6																		
21 JULY	7																1		
24 JULY	10																1		
TOTALS		1	1	0	0	2	12%	0	1	0	0	1	6%	0	0	0	2	2	12%
		IN PLANT 1 MINUTE DELAY BEFORE FLUX REMOVAL																	
			(3)*					(3)						(3)	(3)		(3)		
4 AUG	1																		
7 AUG	4		1																
8 AUG	5																		
9 AUG	6																		
10 AUG	7																		
11 AUG	8																		
14 AUG	11																		
TOTALS		0	1	0	0	1	7%	0	0	0	0	0	0%	0	0	0	0	0	0%

Legend: * ( ) NUMBER OF SPECIMENS IN SET.

[1] FIRST LETTER (A, B, OR C) INDICATES FLUX USED.

[2] NUMBER WILL EITHER BE 0(NO DC VOLTAGE) OR 100(DC VOLTS).

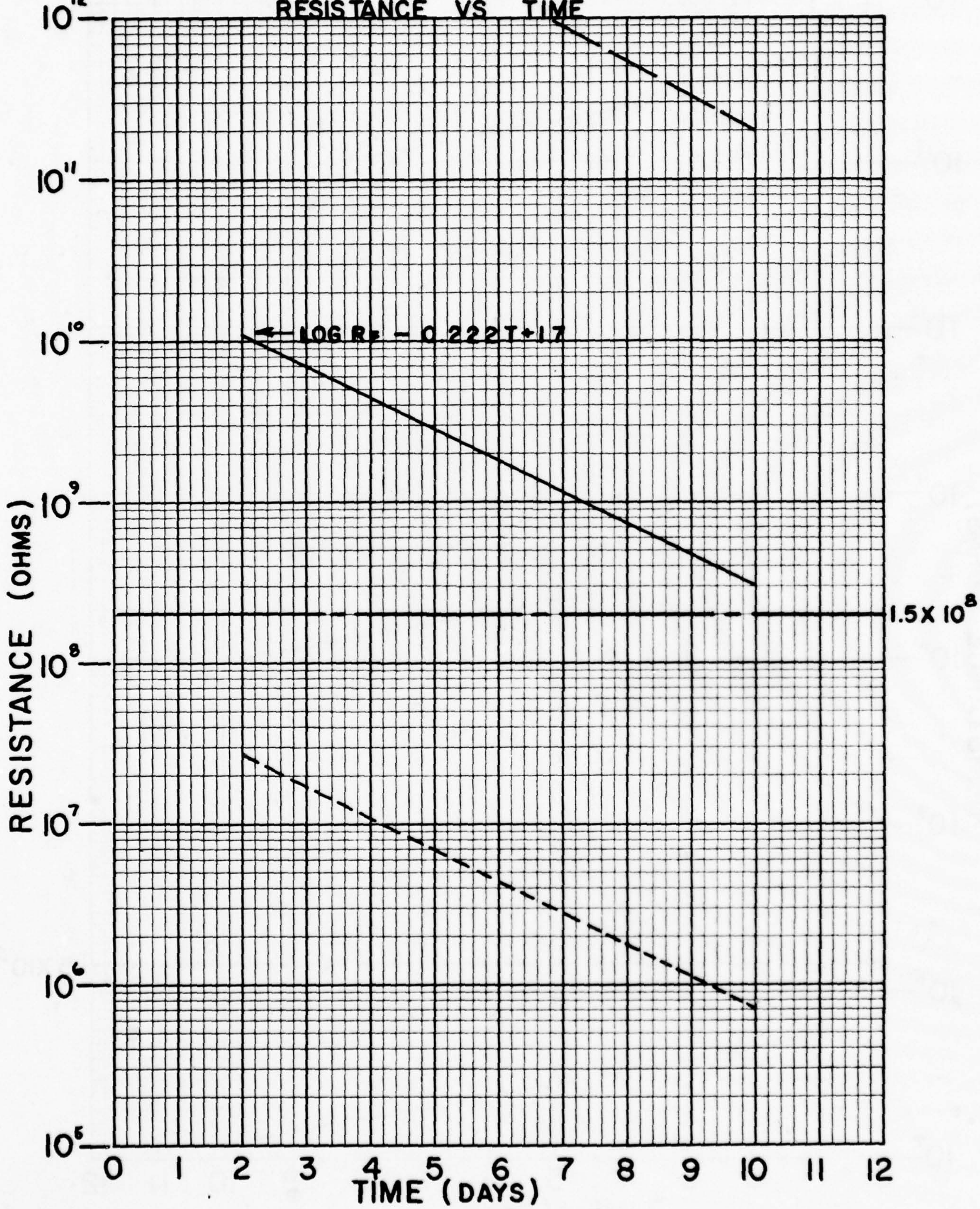
[3] LAST LETTER INDICATES CONFORMAL COATED (C) OR SOLDER MASK (S).

FIGURE 4.

72 HOUR DELAY

A FLUX, 0 VOLTS STRESS, CONFORMALLY COATED

RESISTANCE VS TIME



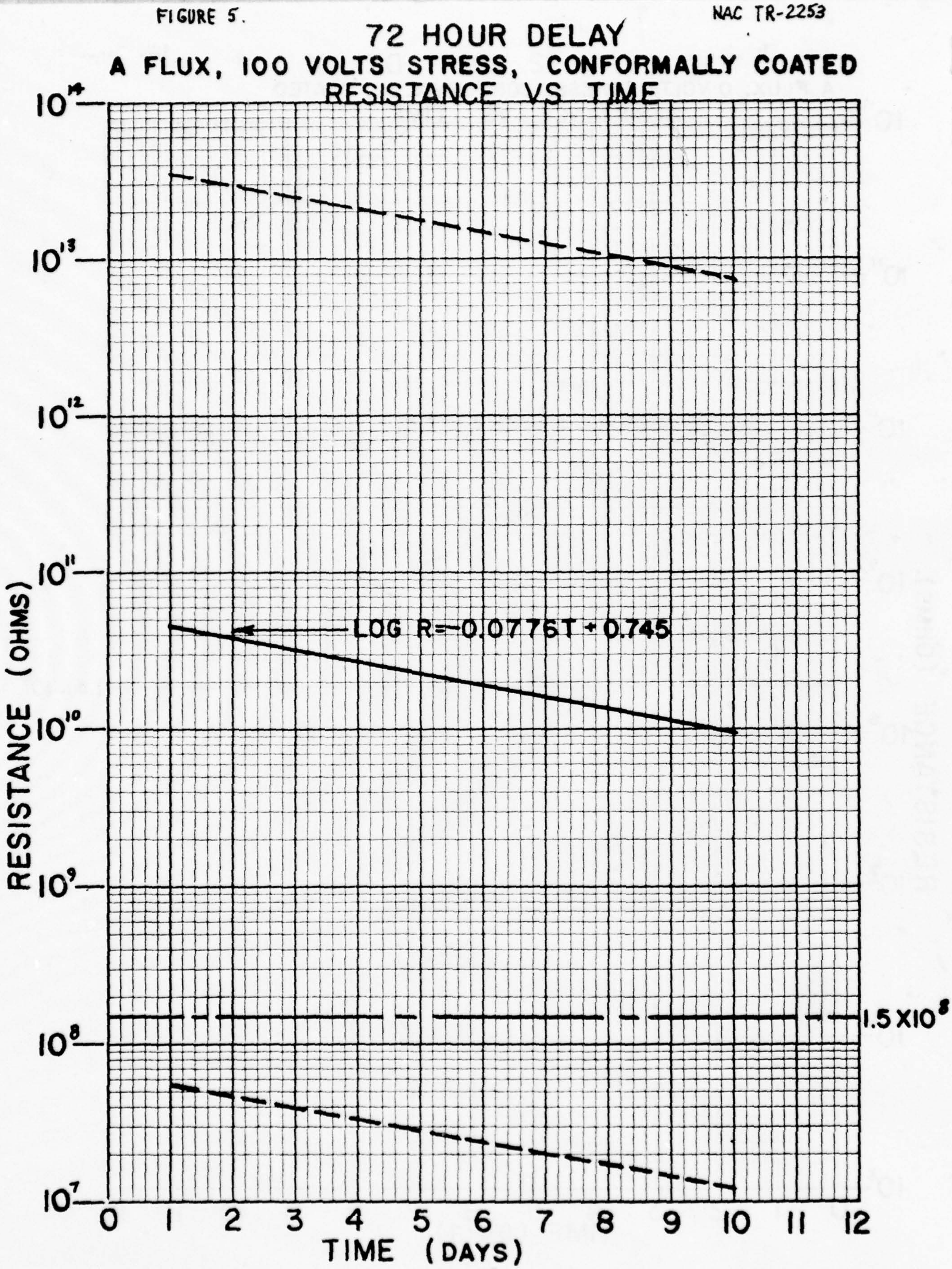
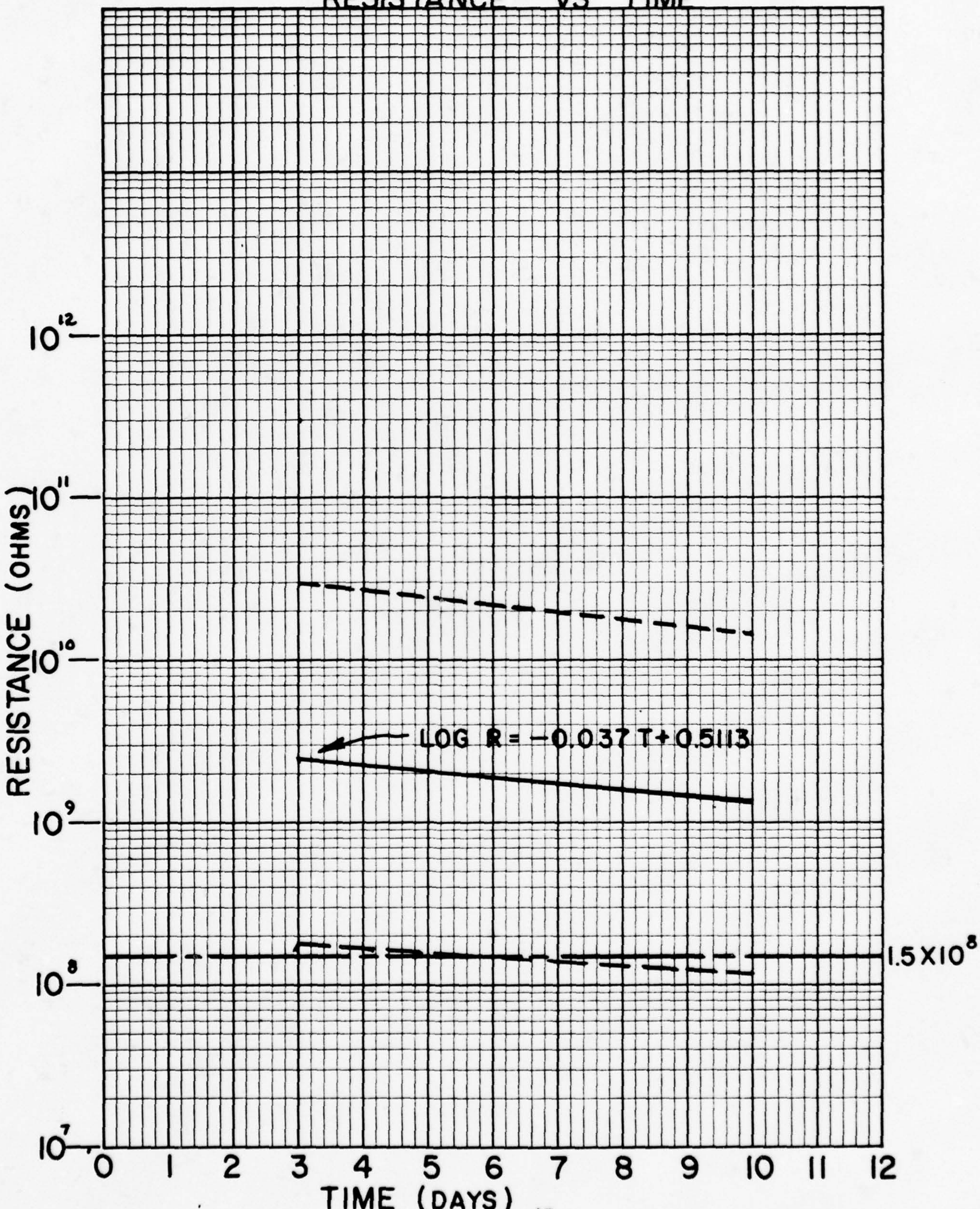

72 HOUR DELAY
A FLUX, 100 VOLTS STRESS, CONFORMALLY COATED
RESISTANCE VS TIME
RESISTANCE (OHMS)
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
LOG R=-0.0776T + 0.745
1.5 X10^{8}
0
1
2
3
4
5
6
7
8
9
10
11
12
TIME (DAYS)

FIGURE 6.

72 HOUR DELAY
CONTROLS
RESISTANCE VS TIME



APPENDIX

EXPLANATION OF PHOTOGRAPHS

3B100C

Laminate attack by "B" Flux subjected to 20 days of temperature and humidity testing per MIL-STD-810C, Method 507.1, Procedure 1 (flux removed).

1C100C

Laminate attack by "C" Flux subjected to 20 days at temperature and humidity testing per MIL-STD-810C, Method 507.1, Procedure 1 (flux removed).

4C100C

Burned out track due to surface resistance deterioration by 20 days of temperature and humidity testing per MIL-STD-810C, Method 507.1, Procedure 1 (no flux removed).

4A100C

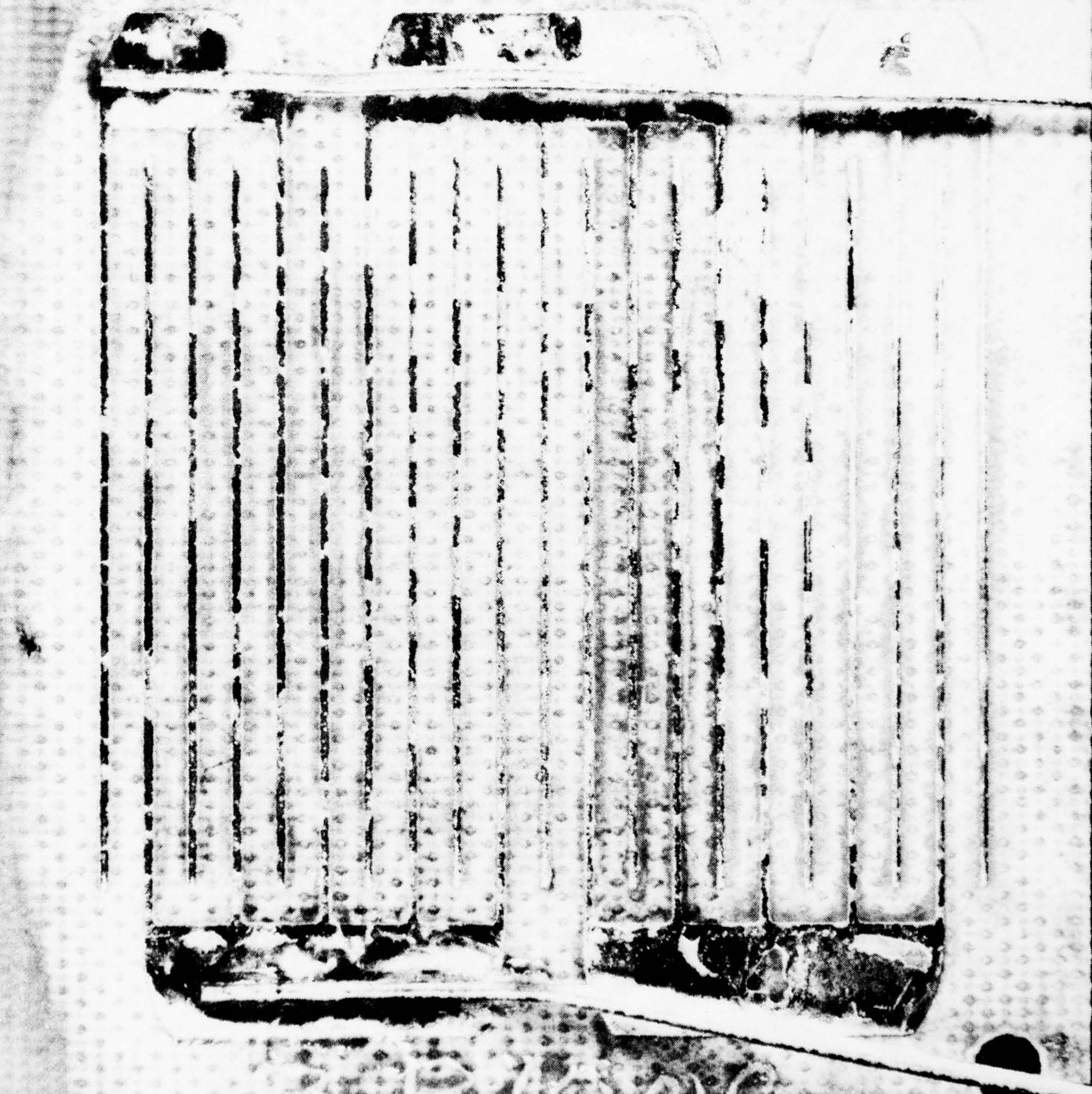
Laminate which had been covered with "A" flux after 20 days of temperature and humidity testing per MIL-STD-810C, Method 507.1, Procedure 1 (flux removed).

2B100S

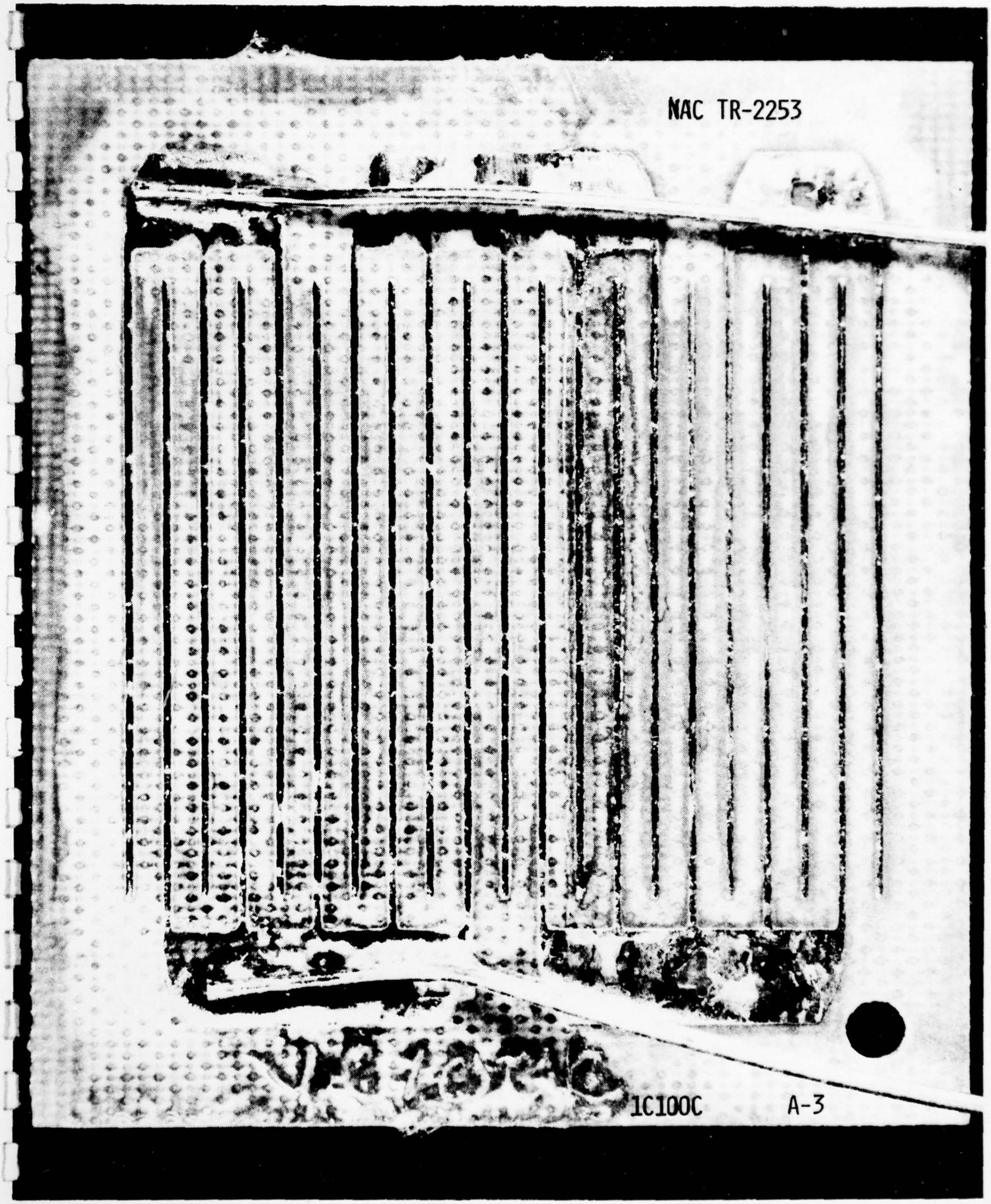
Solder masked area, no laminate attack by "B" Flux subjected to 20 days of temperature and humidity testing per MIL-STD-810C, Method 507.1, Procedure 1 (flux removed).

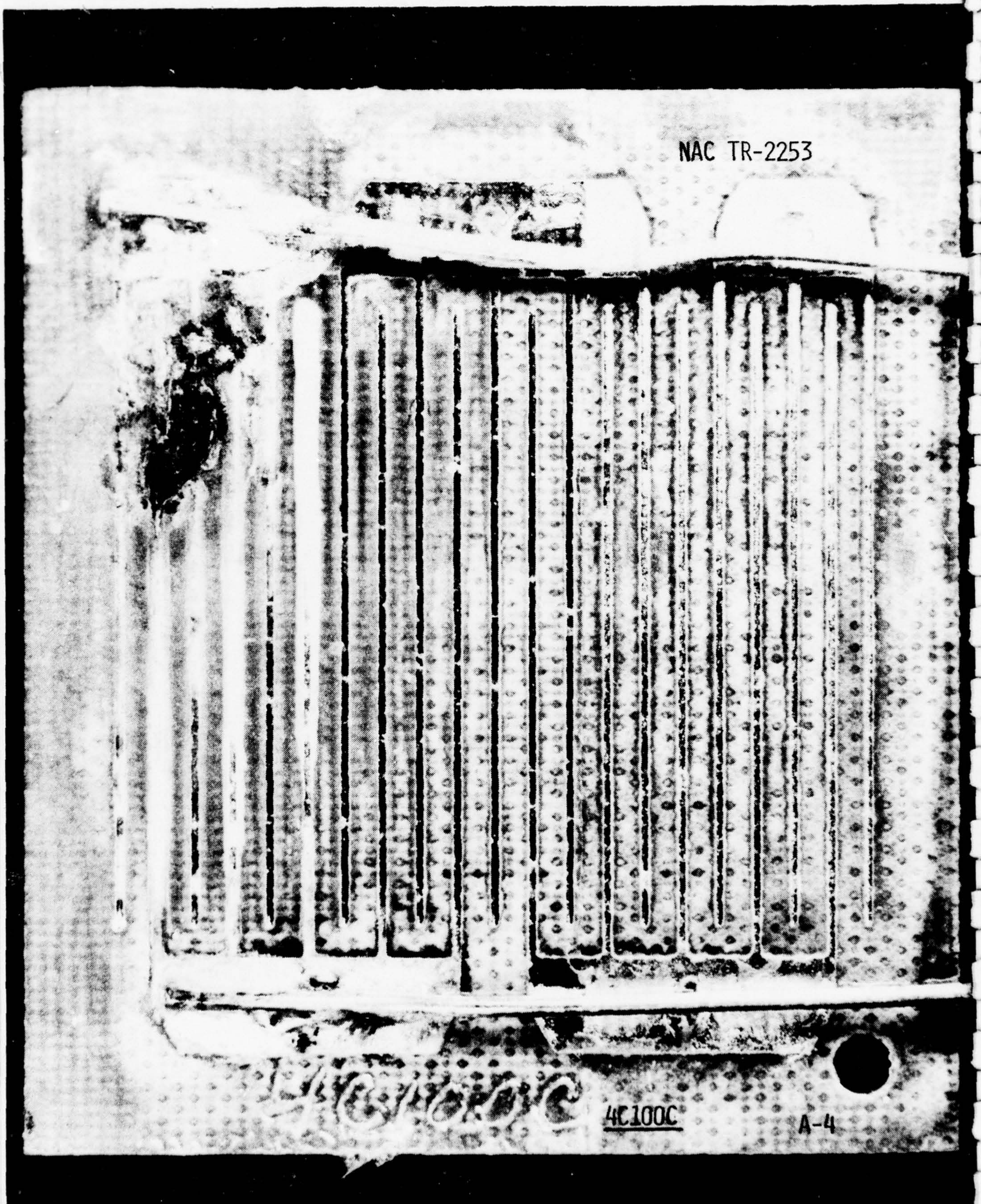
3A100C

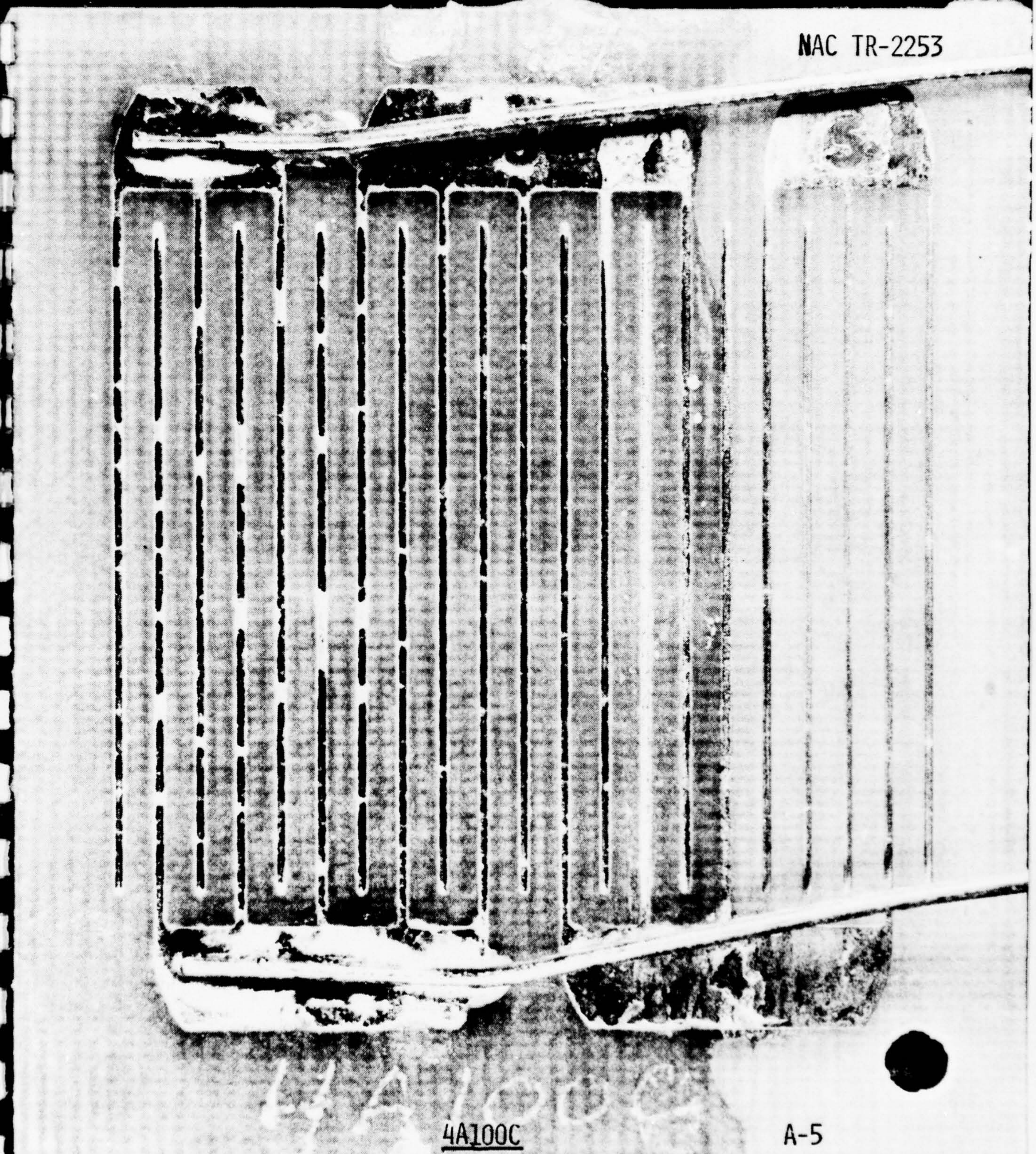
Conformal coating over "A" after 20 days of temperature and humidity testing per MIL-STD-810C, Method 507.1, Procedure 1 (no flux removed).



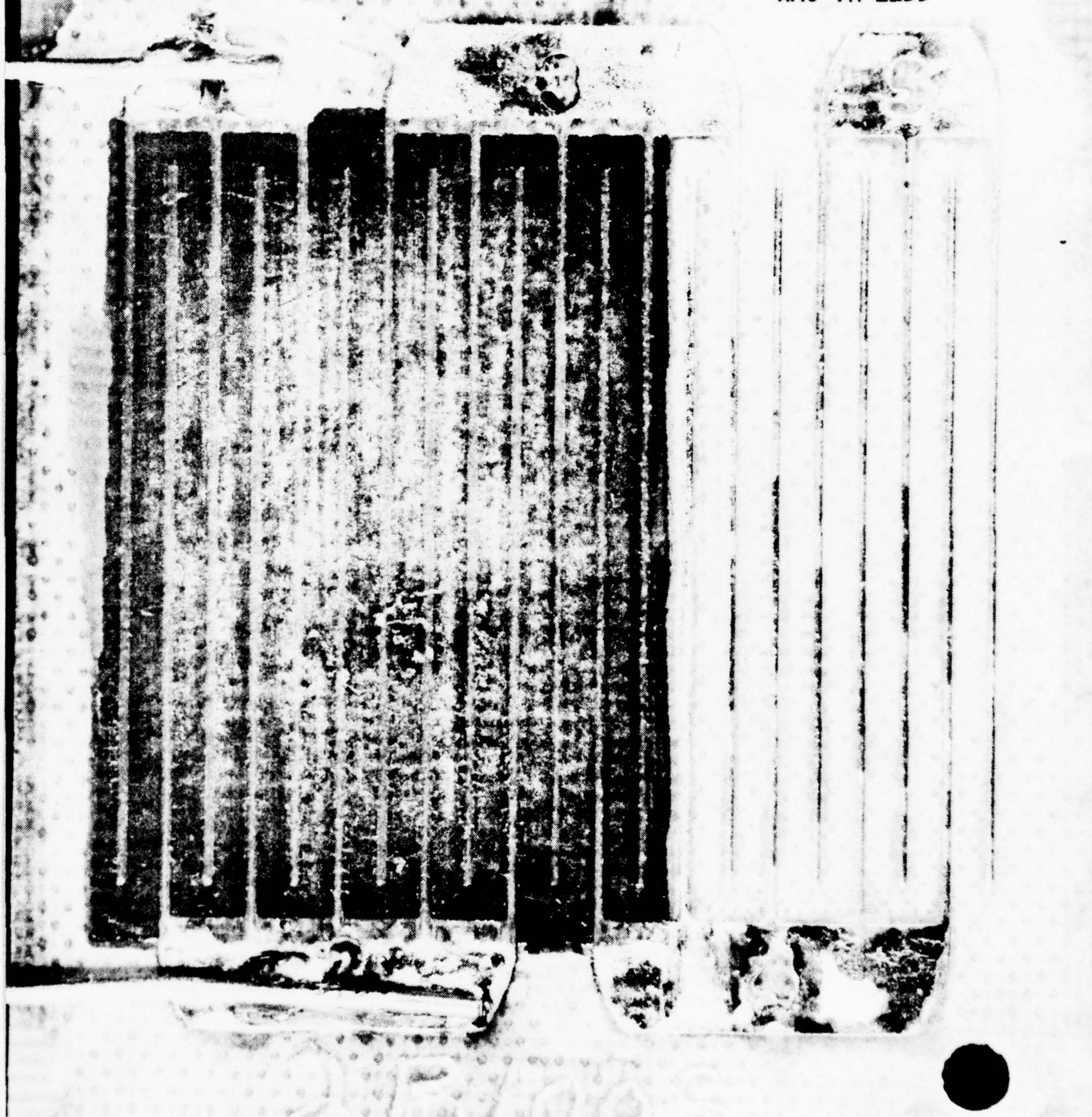
3B100C


1C100C

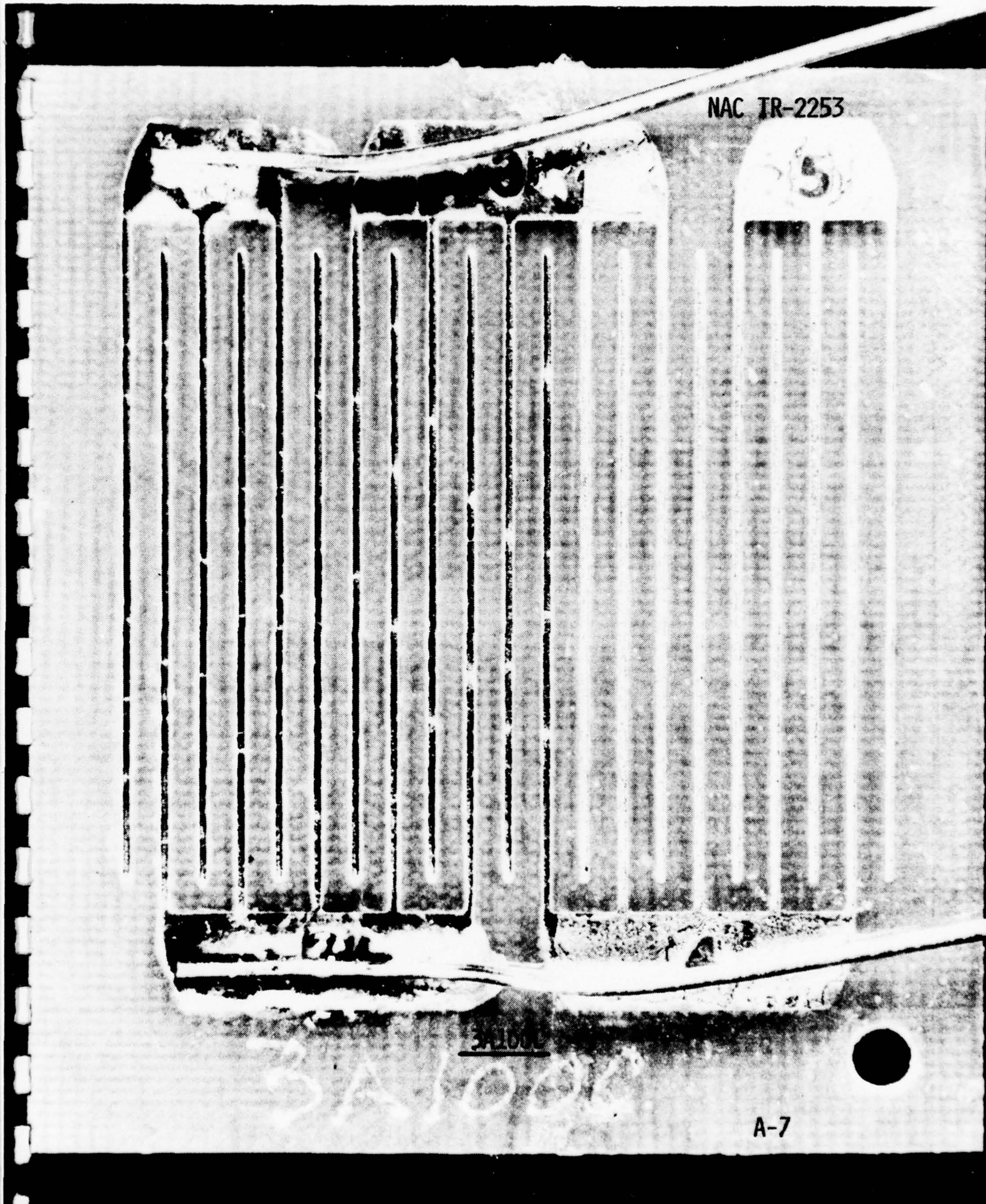

NAC TR-2253
4C100C
A-4



4A100C



2B100S


3A100C
3A100C

RAW DATA

72 HR. DELAY BEFORE FLUX REMOVAL

DAYS	FLUX TYPE (A) CONFORMAL COATED 0 VOLTS — Insulation Resistance - OHMS					FLUX TYPE (A) CONFORMAL COATED 100 VOLTS — Insulation Resistance - OHMS			
	Spec 1	Spec 2	Spec 3	Spec 4	Control#1	Spec 1	Spec 2	Spec 3	Spec 4
3	3.15×10^{11}	4.7×10^{10}	2.05×10^{9}	8×10^{9}	1.7×10^{10}	5.3×10^{10}	1.18×10^{11}	6.5×10^{10}	1.88×10^{10}
5	5.5×10^{7}	2×10^{9}	1.84×10^{9}	3.9×10^{10}	9.4×10^{8}	3.3×10^{8}	10.2×10^{10}	1.84×10^{11}	1.86×10^{10}
6	1.2×10^{8}	3.5×10^{9}	1.81×10^{9}	1.21×10^{10}	7.7×10^{8}	5.3×10^{7}	8.3×10^{10}	10.6×10^{10}	1.8×10^{10}
7	6.5×10^{7}	$.97 \times 10^{10}$	1.9×10^{9}	7.35×10^{9}	1.08×10^{9}	6×10^{8}	8.5×10^{10}	1.23×10^{11}	1.87×10^{10}
10	6.5×10^{7}	5.5×10^{7}	2.1×10^{9}	3.5×10^{9}	1.3×10^{9}	5.0×10^{8}	4.8×10^{10}	5.5×10^{10}	1.68×10^{10}
	SOLDER MASK 0 VOLTS				Control#2	SOLDER MASK 100 VOLTS			
3	4.5×10^{10}	7.6×10^{10}	5.4×10^{9}	5×10^{8}	1.66×10^{9}	4.75×10^{10}	1.58×10^{10}	1.74×10^{10}	2.9×10^{10}
5	9×10^{10}	1.56×10^{9}	9.6×10^{8}	3.95×10^{8}	1.52×10^{9}	4.15×10^{10}	1.52×10^{10}	1.62×10^{10}	2.3×10^{10}
6	5.6×10^{10}	5.7×10^{10}	4.65×10^{9}	5.9×10^{9}	1.64×10^{9}	3.9×10^{10}	1.32×10^{10}	1.54×10^{10}	1.9×10^{10}
7	2.95×10^{9}	4×10^{10}	10.2×10^{9}	8.4×10^{9}	2.55×10^{9}	3.35×10^{10}	1.47×10^{10}	1.7×10^{10}	1.72×10^{10}
10	6.2×10^{9}	1.7×10^{9}	1.14×10^{10}	1.2×10^{10}	3.5×10^{9}	11.0×10^{9}	1.34×10^{10}	1.5×10^{10}	1.58×10^{10}

RAW DATA

72 HR. DELAY BEFORE FLUX REMOVAL

FLUX TYPE (B) — CONFORMAL COATED 0 VOLTS | FLUX TYPE (B) — CONFORMAL COATED 100 VOLTS

DAYS	Insulation Resistance - OHMS				Insulation Resistance - OHMS			
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 1	Spec 2	Spec 3	Spec 4
3	$7.9.10^{9}$	$3.75x10^{7}$	$1.3x10^{9}$	$8.2x10^{8}$	$5.9x10^{11}$	$1.84x10^{12}$	$7.3x10^{10}$	$4.35x10^{11}$
5	$3.3x10^{9}$	$3x10^{7}$	$1.18x10^{10}$	$1.26x10^{10}$	$1.34x10^{9}$	$1.2x10^{10}$	$4.6x10^{10}$	$2.3x10^{10}$
6	$4.9x10^{9}$	$2.45x10^{7}$	$1.1x10^{10}$	$1.6x10^{10}$	$1x10^{9}$	$1x10^{10}$	$3.95x10^{10}$	$2.2x10^{10}$
7	$4.6x10^{9}$	$2.6x10^{7}$	$1.27x10^{10}$	$1.08x10^{10}$	$27x10^{7}$	$1.8x10^{10}$	$3.95x10^{10}$	$23x20^{10}$
10	$2.45x10^{9}$	$1.85x10^{7}$	$4.0x10^{9}$	$7.10x10^{9}$	$15x10^{12}$	$27x10^{12}$	$11x10^{12}$	$18x10^{12}$
	SOLDER MASK 0 VOLTS				SOLDER MASK 100 VOLTS			
3	$1.66x10^{10}$	$9x10^{10}$	$3.3x10^{10}$	$3.35x10^{10}$	$2.85x10^{11}$	$2.05x10^{11}$	$2.45x10^{12}$	$1.14x10^{11}$
5	$2.65x10^{9}$	$2.7x10^{10}$	$6.4x10^{9}$	$5.1x10^{9}$	$2.75x10^{10}$	$2.05x10^{10}$	$1.04x10^{11}$	$1.68x10^{10}$
6	$2.1x10^{9}$	$2.85x10^{10}$	$5.3x10^{9}$	$3.8x10^{9}$	$2.5x10^{10}$	$2x10^{10}$	$1.22x10^{11}$	$1.66x10^{10}$
7	$2.1x10^{9}$	$1.74x10^{9}$	$4.85x10^{9}$	$3.1x10^{9}$	$1.62x10^{10}$	$1.93x10^{10}$	$6.4x10^{10}$	$1.74x10^{10}$
10	$30x10^{12}$	$1.54x10^{10}$	$5.8x10^{9}$	$4.1x10^{9}$	$24x10^{12}$	$21x10^{12}$	$24x10^{12}$	$30x10^{12}$

RAW DATA

72 HR. DELAY BEFORE FLUX REMOVAL

DAYS	FLUX TYPE (C) CONFORMAL COATED 0 VOLTS				FLUX TYPE (C) CONFORMAL COATED 100 VOLTS			
	Insulation Resistance - OHMS				Insulation Resistance - OHMS			
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 1	Spec 2	Spec 3	Spec 4
3	3.65×10^{10}	3.4×10^{10}	2.5×10^{10}	8.4×10^{10}	1.5×10^{11}	2.45×10^{11}	1.72×10^{11}	1.76×10^{11}
5	1.7×10^{10}	9.4×10^{8}	5.6×10^{8}	4.9×10^{8}	1.2×10^{8}	1.84×10^{10}	1.4×10^{10}	1.86×10^{10}
6	1.28×10^{10}	2.15×10^{9}	4.85×10^{9}	2.7×10^{9}	9.2×10^{7}	1.8×10^{10}	8.8×10^{9}	1.84×10^{10}
7	2.2×10^{10}	3.2×10^{9}	8.4×10^{9}	2.75×10^{9}	9.0×10^{7}	1.92×10^{10}	7.3×10^{9}	21×10^{9}
10	3.5×10^{10}	8.5×10^{9}	8.2×10^{8}	4.95×10^{9}	4.2×10^{8}	1.32×10^{10}	2.2×10^{9}	2.1×10^{10}
	SOLDER MASK 0 VOLTS				SOLDER MASK 100 VOLTS			
3	9.7×10^{9}	2.8×10^{9}	2×10^{9}	8.7×10^{9}	1.4×10^{11}	1.48×10^{11}	1.6×10^{11}	1.64×10^{11}
5	2.9×10^{9}	2.6×10^{9}	2.45×10^{9}	9×10^{9}	6.8×10^{9}	1.98×10^{10}	3.5×10^{9}	1.48×10^{10}
6	3.3×10^{9}	2.9×10^{9}	2.5×10^{9}	8.2×10^{9}	9.4×10^{9}	6.5×10^{9}	3.5×10^{9}	8.4×10^{9}
7	3.75×10^{9}	3.2×10^{9}	2.85×10^{9}	7.6×10^{9}	6.5×10^{9}	1.72×10^{10}	4.5×10^{9}	3.7×10^{9}
10	5.9×10^{9}	5.6×10^{9}	3.5×10^{9}	8.5×10^{8}	8.4×10^{9}	1.48×10^{10}	2.0×10^{9}	8.5×10^{9}

RAW DATA

168 HR. DELAY BEFORE FLUX REMOVAL

FLUX TYPE (A) CONFORMAL COATED 0 VOLTS | FLUX TYPE (A) CONFORMAL COATED 100 VOLTS

DAYS	Insulation Resistance - OHMS					Insulation Resistance - OHMS			
	Spec 1	Spec 2	Spec 3	Spec 4	Control #1	Spec 1	Spec 2	Spec 3	Spec 4
3	$3.2x10^8$	$3.1x10^9$	$2.5x10^9$	$1.72x10^9$	$2.35x10^9$	$9.0x10^8$	$5.5x10^{10}$	$9.3x10^{10}$	$2.3x10^{10}$
4	$2.15x10^8$	$6.1x10^9$	$2.52x10^9$	$7.7x10^9$	$2.4x10^9$	$6.7x10^7$	$5.0x10^{10}$	$5.1x10^{10}$	$2.0x10^{10}$
5	$18x10^7$	$3.3x10^9$	$2.8x10^9$	$2.15x10^9$	$3.1x10^9$	$4.9x10^7$	$0.94x10^{11}$	$7.1x10^{10}$	$2.4x10^{10}$
6	$1.3x10^8$	$1.24x10^{10}$	$2.95x10^9$	$4.35x10^{10}$	$2.55x10^9$	$4.2x10^7$	$2.55x10^{10}$	$3.5x10^{10}$	$1.84x10^{10}$
7	$2.7x10^7$	$3.3x10^9$	$3.1x10^9$	$19x10^8$	$3.1x10^9$	$3.0x10^7$	$2.4x10^{10}$	$5.5x10^{10}$	$2.15x10^{10}$
10	$7.3x10^7$	$3.54x10^9$	$5.2x10^9$	$9.7x10^8$	$2.2x10^9$	$2.8x10^7$	$4.0x10^{10}$	$7.0x10^{10}$	$2.2x10^{10}$
	SOLDER MASK 0 VOLTS				Control #2	SOLDER MASK 100 VOLTS			
3	$6.9x10^{10}$	$1.47x10^{10}$	$2.25x10^{10}$	$2.3x10^{10}$	$3.3x10^9$	$7.3x10^{10}$	$1.4x10^{10}$	$2.5x10^{10}$	$2.25x10^{10}$
4	$1.9x10^9$	$4.1x10^9$	$6.0x10^8$	$5.6x10^8$	$5.5x10^8$	$6.5x10^{10}$	$1.36x10^{10}$	$2.5x10^{10}$	$2.05x10^{10}$
5	$1.74x10^9$	$4.7x10^8$	$5.8x10^8$	$5.6x10^8$	$1.9x10^8$	$5.6x10^{10}$	$1.48x10^{10}$	$2.55x10^{10}$	$1.95x10^{10}$
6	$1.6x10^9$	$1.78x10^9$	$4.25x10^{10}$	$4.65x10^8$	$1.58x10^9$	$4.7x10^{10}$	$1.34x10^{10}$	$2.15x10^{10}$	$1.61x10^{10}$
7	$1.7x10^9$	$3.2x10^9$	$6.5x10^8$	$4.2x10^8$	$1.54x10^9$	$1.16x10^{10}$	$1.3x10^{10}$	$2.0x10^{10}$	$1.7x10^{10}$
10	$12.4x10^8$	$14.6x10^{10}$	$5.1x10^8$	$3.3x10^8$	$2.2x10^9$	$2.5x10^{10}$	$1.2x10^{10}$	$2.0x10^{10}$	$1.56x10^{10}$

RAW DATA

168 HR. DELAY BEFORE FLUX REMOVAL

DAYS	FLUX TYPE (B) CONFORMAL COATING 0 VOLTS — Insulation Resistance - OHMS					FLUX TYPE (B) CONFORMAL COATED 100 VOLTS — Insulation Resistance - OHMS			
	Spec 1	Spec 2	Spec 3	Spec 4	Control#3	Spec 1	Spec 2	Spec 3	Spec 4
3	$1.3x10^{9}$	$1.3x10^{9}$	$1.6x10^{9}$	$4.3x10^{9}$	$2.2x10^{9}$	$2.5x10^{9}$	$3.25x10^{10}$	$3.7x10^{10}$	$2.1x10^{7}$
4	$1.44x10^{9}$	$1.44x10^{9}$	$7.1x10^{8}$	$3.95x10^{9}$	$2.15x10^{10}$	$2.05x10^{10}$	$4.15x10^{9}$	$3.1x10^{10}$	$2.05x10^{7}$
5	$2.1x10^{9}$	$1.18x10^{10}$	$7.7x10^{8}$	$5.3x10^{9}$	$18.5x10^{9}$	$3.5x10^{9}$	$4.35x10^{10}$	$3.86x10^{10}$	$2.04x10^{7}$
6	$2.8x10^{9}$	$1.27x10^{9}$	$10x10^{8}$	$4.9x10^{9}$	$2.0x10^{10}$	$6.8x10^{8}$	$4.0x10^{10}$	$4.1x10^{10}$	$2.0x10^{7}$
7	$7.1x10^{8}$	$2.7x10^{9}$	$7.8x10^{8}$	$4.2x10^{9}$	$2.1x10^{10}$	$12.2x10^{8}$	$4.5x10^{10}$	$3.8x10^{10}$	$2.0x10^{7}$
10	$2.5x10^{9}$	$7.0x10^{8}$	$5.1x10^{8}$	$3.7x10^{9}$	$3.1x10^{10}$	$13.8x10^{10}$	$2.8x10^{10}$	$2.5x10^{10}$	$5.3x10^{6}$
	SOLDER MASK 0 VOLTS					SOLDER MASK 100 VOLTS			
3	$1.54x10^{9}$	$12.0x10^{8}$	$4.6x10^{8}$	$2.6x10^{9}$		$2.3x10^{10}$	$1.94x10^{10}$	$5.7x10^{10}$	$2.25x10^{10}$
4	$7.4x10^{9}$	$1.32x10^{9}$	$1.36x10^{9}$	$3x10^{9}$		$2.15x10^{10}$	$4.95x10^{10}$	$2.25x10^{10}$	$2.25x10^{10}$
5	$1.97x10^{9}$	$1.18x10^{9}$	$3.15x10^{9}$	$3x10^{9}$		$2.0x10^{10}$	$1.73x10^{10}$	$4.0x10^{10}$	$2.15x10^{10}$
6	$1.94x10^{9}$	$1.8x10^{9}$	$5.9x10^{8}$	$2.8x10^{9}$		$1.92x10^{10}$	$1.62x10^{10}$	$3.6x10^{10}$	$2.1x10^{10}$
7	$1.82x10^{9}$	$1.8x10^{9}$	$3.8x10^{9}$	$2.7x10^{9}$		$1.84x10^{10}$	$1.56x10^{10}$	$3.2x10^{10}$	$1.98x10^{10}$
10	$1.4x10^{9}$	$5.1x10^{8}$	$2.5x10^{8}$	$2.1x10^{9}$		$1.6x10^{10}$	$1.42x10^{10}$	$2.5x10^{10}$	$1.6x10^{10}$

RAW DATA

168 HR. DELAY BEFORE FLUX REMOVAL

DAYS	FLUX TYPE (C) CONFORMAL COATED 0 VOLTS — Insulation Resistance - OHMS				FLUX TYPE (C) CONFORMAL COATED 100 VOLTS — Insulation Resistance - OHMS			
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 1	Spec 2	Spec 3	Spec 4
3	$1.6x10^9$	$1.14x10^9$	$7.8x10^8$	$4.0x10^8$	$17.0x10^9$	$1.46x10^{10}$	$1.56x10^{10}$	$1.72x10^{10}$
4	$8.6x10^9$	$2.75x10^9$	$3.25x10^9$	$7.1x10^9$	$1.8x10^{10}$	$1.24x10^{10}$	$1.52x10^{10}$	$1.7x10^{10}$
5	$2.8x10^{10}$	$8.7x10^9$	$9.1x10^9$	$1.56x10^{10}$	$1.84x10^{10}$	$1.15x10^{10}$	$1.56x10^{10}$	$1.68x10^{10}$
6	$14.2x10^{10}$	$1.08x10^{10}$	$2.7x10^{10}$	$8.7x10^8$	$1.8x10^{10}$	$1.08x10^{10}$	$1.52x10^{10}$	$1.7x10^{10}$
7	$2.3x10^9$	$1.84x10^9$	$1.6x10^9$	$7.0x10^9$	$1.9x10^{10}$	$1.06x10^{10}$	$1.52x10^{10}$	$1.7x10^{10}$
10	$1.48x10^9$	$6.2x10^8$	$7.5x10^8$	$3.2x10^8$	$1.68x10^{10}$	$6.2x10^9$	$1.34x10^{10}$	$1.58x10^{10}$
	SOLDER MASK 0 VOLTS				SOLDER MASK 100 VOLTS			
3	$1.8x10^9$	$8.3x10^8$	$10.0x10^8$	$7.7x10^9$	$1.84x10^{10}$	$1.54x10^{10}$	$2.2x10^{10}$	$1.78x10^{10}$
4	$1.42x10^9$	$3.55x10^9$	$1.5x10^9$	$1.07x10^{10}$	$1.78x10^{10}$	$1.44x10^9$	$1.9x10^{10}$	$1.76x10^{10}$
5	$1.47x10^9$	$2.56x10^9$	$2.3x10^9$	$1.34x10^{10}$	$1.84x10^{10}$	$1.68x10^{10}$	$1.75x10^{10}$	$1.54x10^{10}$
6	$1.6x10^9$	$3.52x10^9$	$3.2x10^9$	$4.1x10^{10}$	$1.7x10^{10}$	$1.6x10^{10}$	$1.28x10^{10}$	$1.44x10^{10}$
7	$1.48x10^9$	$5.0x10^9$	$3.9x10^9$	$1.8x10^9$	$1.6x10^{10}$	$1.6x10^{10}$	$5.0x10^6$	$1.34x10^{10}$
10	$1.02x10^9$	$1.74x10^{10}$	$1.52x10^{10}$	$8x10^8$	$1.56x10^{10}$	$1.38x10^{10}$	$5x10^6$	$6x10^6$

RAW DATA

IN PLANT, WAVE SOLDERED AND CLEANED
1 MINUTE DELAY BEFORE FLUX REMOVAL

FLUX TYPE (A) — CONFORMAL COATED — 0 VOLTS | FLUX TYPE (A) — CONFORMAL COATED — 100 VOLTS

DAYS	Insulation Resistance - OMHS (0 VOLTS)				Insulation Resistance - OMHS (100 VOLTS)			
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 1	Spec 2	Spec 3	
1	1.09×10^{10}	7.0×10^{9}	9.2×10^{9}	1.3×10^{9}	1.74×10^{11}	3.3×10^{10}	2.5×10^{10}	
4	2.4×10^{8}	6.5×10^{9}	6.7×10^{9}	2.1×10^{9}	1.34×10^{8}	6.8×10^{10}	1.5×10^{11}	
5	7×10^{9}	4.3×10^{10}	3.9×10^{9}	3.5×10^{10}	2.5×10^{9}	3.1×10^{11}	1.76×10^{11}	
6	1.3×10^{9}	1.62×10^{11}	1.02×10^{10}	5.2×10^{9}	2.6×10^{9}	2.6×10^{11}	1.8×10^{11}	
7	1.2×10^{9}	4.5×10^{9}	2.3×10^{10}	3.2×10^{9}	1.9×10^{9}	2.5×10^{11}	2.0×10^{11}	
8	3.0×10^{9}	1.52×10^{10}	2.54×10^{10}	4.1×10^{10}	2.1×10^{9}	2.5×10^{11}	- -	
11	2.5×10^{9}	5.0×10^{10}	5.4×10^{10}	5.7×10^{9}	4.5×10^{8}	2.3×10^{11}	- -	
	SOLDER MASK 0 VOLTS				SOLDER MASK 100 VOLTS			
1	1.38×10^{9}	1.34×10^{9}	3.59×10^{8}	2.9×10^{8}	2.4×10^{11}	1.5×10^{10}	2.2×10^{10}	1.76×10^{10}
4	2.5×10^{9}	2.1×10^{9}	1.06×10^{9}	7.2×10^{8}	10.4×10^{10}	2.3×10^{10}	3.0×10^{10}	2.6×10^{10}
5	1.48×10^{11}	9.0×10^{9}	6.0×10^{10}	6.0×10^{9}	16.0×10^{11}	9.7×10^{10}	10.0×10^{10}	1.2×10^{11}
6	1.1×16^{11}	1.58×10^{10}	8.3×10^{9}	2.6×10^{10}	4.7×10^{11}	8.4×10^{10}	1×10^{11}	1.08×10^{11}
7	3.0×10^{10}	4.9×10^{10}	4.0×10^{9}	6.0×10^{9}	3.6×10^{11}	10.3×10^{10}	1.5×10^{11}	1.2×10^{11}
8	2.54×10^{10}	11.2×10^{11}	4.52×10^{9}	9.0×10^{9}	1.06×10^{11}	9.6×10^{10}	1.06×10^{11}	1.2×10^{11}
11	5.5×10^{9}	1.4×10^{10}	3.5×10^{9}	2.0×10^{9}	1.8×10^{12}	10.0×10^{10}	1.1×10^{11}	1.16×10^{11}

RAW DATA

IN PLANT, WAVE SOLDERED AND CLEANED
1 MINUTE DELAY BEFORE FLUX REMOVAL

FLUX TYPE (B) CONFORMAL COATED 0 VOLTS — FLUX TYPE (B) CONFORMAL COATED 100 VOLTS

DAYS	Insulation Resistance - OHMS				Insulation Resistance - OHMS			
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 1	Spec 2	Spec 3	Spec 4
1	$1.8x10^{10}$	$4.5x10^{10}$	$4.51x10^{8}$		$11.2x10^{10}$	$5.4x10^{9}$	$2.3x10^{10}$	$2.4x10^{10}$
4	$1.66x10^{9}$	$16.0x10^{8}$	$4.0x10^{8}$		$2.5x10^{9}$	$1.3x10^{10}$	$1.96x10^{11}$	$2.4x10^{11}$
5	$3.0x10^{10}$	$1.32x16^{10}$	$8.4x10^{9}$		$1.87x10^{11}$	$4.65x10^{11}$	$6.5x10^{11}$	$1.84x10^{11}$
6	$4.6x10^{10}$	$1.7x10^{11}$	- -		$3.6x10^{11}$	$2.8x10^{11}$	$1.22x10^{12}$	$2.4x10^{11}$
7	$1.2x10^{10}$	$6.5x10^{10}$	$3.4x10^{10}$		$6.5x10^{11}$	$4.3x10^{11}$	$4.0x10^{11}$	$2.7x10^{11}$
8	$1.56x10^{10}$	$2.56x10^{10}$	$4.0x10^{10}$		$2.5x10^{11}$	$4.2x10^{11}$	$2.58x10^{11}$	$2.1x10^{11}$
11	$6.5x10^{9}$	$11.4x10^{9}$	$6.4x10^{9}$		$8.0x10^{10}$	$2.2x10^{11}$	$7.0x10^{11}$	$1.96x10^{11}$
	SOLDER MASK 0 VOLTS				SOLDER MASK 100 VOLTS			
1	$2.4x10^{9}$	$7.4x10^{8}$	$3.9x10^{9}$	$9.5x10^{9}$	$4.0x10^{10}$	$2.3x10^{10}$	$1.15x10^{11}$	$2.3x10^{10}$
4	$2.3x10^{10}$	$2.2x10^{10}$	$5.9x10^{10}$	$12.0x10^{9}$	$2.5x10^{11}$	$16.0x10^{10}$	$6.0x10^{11}$	$1.72x10^{11}$
5	$2.5x10^{10}$	$2.95x10^{10}$	$4.8x10^{10}$	$1.4x10^{11}$	$2.4x10^{11}$	$12.5x10^{10}$	$7.3x10^{11}$	$1.1x10^{11}$
6	$3.45x10^{10}$	$6.3x10^{10}$	$1.2x10^{10}$	- -	$2.5x10^{11}$	$1.26x10^{11}$	$1.82x10^{12}$	$1.04x10^{11}$
7	$3.5x10^{10}$	$2.2x10^{10}$	$5.0x10^{9}$	- -	$2.4x10^{11}$	$1.3x10^{11}$	$9.0x10^{11}$	$1.08x10^{11}$
8	$4.0x10^{10}$	$15.5x10^{9}$	$5.7x10^{11}$	$7.3x10^{9}$	$2.58x10^{11}$	$13.2x10^{10}$	$7.7x10^{11}$	$1.12x10^{11}$
11	$8.5x10^{10}$	$4.5x10^{9}$	$8.4x10^{9}$	$10.0x10^{9}$	$3.5x10^{11}$	$1.24x10^{11}$	$3.5x10^{11}$	$1.16x10^{11}$

RAW DATA

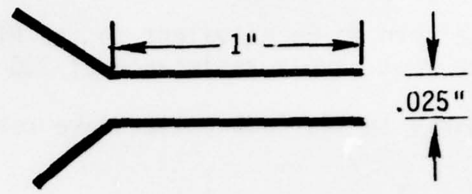
IN PLANT, WAVE SOLDERED AND CLEANED
1 MINUTE DELAY BEFORE FLUX REMOVAL

FLUX TYPE (C)
CONFORMAL COATED
0 VOLTS

FLUX TYPE (C)
CONFORMAL COATED
100 VOLTS

DAYS	Insulation Resistance - OHMS (0 VOLTS)				Insulation Resistance - OHMS (100 VOLTS)		
	Spec 1	Spec 2	Spec 3	Spec 4	Spec 1	Spec 2	Spec 3
1	4.5×10^{11}	2.5×10^{10}	6.5×10^{9}		2.3×10^{10}	15.0×10^{9}	2.1×10^{10}
4	1.8×10^{10}	6.0×10^{9}	4.1×10^{10}		1.8×10^{11}	14.0×10^{10}	1.64×10^{11}
5	2.6×10^{10}	1.6×10^{11}	1.4×10^{11}		1.8×10^{11}	9.5×10^{10}	1.4×10^{11}
6	2.7×10^{10}	3.1×10^{10}	3.4×10^{10}		2.05×10^{11}	9.4×10^{10}	1.34×10^{11}
7	3.2×10^{10}	18.5×10^{9}	2.6×10^{11}		2.5×10^{11}	9.5×10^{10}	1.4×10^{11}
8	8.5×10^{9}	11.0×10^{9}	3.1×10^{11}		2.54×10^{11}	10.6×10^{10}	1.58×10^{11}
11	5.0×10^{11}	6.4×10^{9}	7.0×10^{9}		1.98×10^{11}	9.9×10^{10}	3.52×10^{10}
	SOLDER MASK 0 VOLTS				SOLDER MASK 100 VOLTS		
1	1.84×10^{10}	13.6×10^{8}	2.5×10^{9}	1.4×10^{10}	1.54×10^{10}	1.88×10^{10}	4.53×10^{9}
4	8.5×10^{10}	5.5×10^{10}	3.2×10^{10}	11.0×10^{9}	1.36×10^{11}	1.6×10^{11}	1.7×10^{11}
5	7.4×10^{10}	8.8×10^{10}	3.7×10^{10}	1.5×10^{10}	12.2×10^{10}	12.6×10^{10}	12.0×10^{10}
6	7.5×10^{10}	2.5×10^{11}	5.1×10^{10}	4×10^{10}	1.08×10^{11}	1.28×10^{11}	1.1×10^{11}
7	1.7×10^{10}	10.2×10^{9}	5.2×10^{10}	8.3×10^{9}	1.1×10^{11}	1.5×10^{11}	1.22×10^{11}
8	7.9×10^{10}	2.0×10^{10}	5.3×10^{10}	15.0×10^{9}	1.2×10^{11}	2.2×10^{11}	1.36×10^{11}
11	5.8×10^{10}	15.5×10^{9}	2.9×10^{10}	3.56×10^{9}	1.1×10^{11}	8.6×10^{10}	- -

EQUILIBRATION OF COMB PATTERN TO MIL-P-55110 TRUMPET PATTERN



MIL-P-55110 TRUMPET PATTERN

1. Number of resistance squares

$$\frac{1.00"}{.025"} = 40 \text{ squares}$$

2. Assume the squares are resistors connected in parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots \frac{1}{R_{40}}$$

$$\frac{1}{R_T} = \frac{40}{R_S}$$

Where $R_T = 500 \times 10^6$ ohms per MIL-P-55110

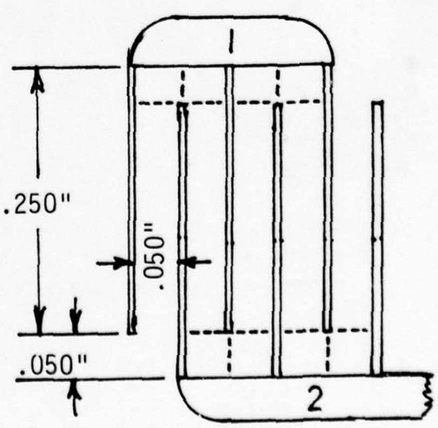
R_S = resistance of each square.

3. $R_T = \dfrac{R_S}{40}$

4. $500 \times 10^6 = \dfrac{R_S}{40}$

$$R_S = 200 \times 10^8 \text{ ohms}$$

Resistance measured portion of comb pattern specimen



5. Number of resistance squares

$\frac{1.250"-.050"}{.050"}$ x 5 + 8 corner squares at the ends of the conductors = 128 squares.

6. For this comb pattern to be eqivalent to the MIL-P-55110 trumpet pattern, each square must have a resistance of 200 x 10^8 ohms.

7. Assumes the squares in the comb pattern are resistors in parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots \frac{1}{R_{128}}$$

$$\frac{1}{R_T} = \frac{128}{R_S}$$

where

R_T = total resistance

R_S = 200 x 10^8 ohms

8. $$R_T = \frac{R_S}{128}$$

9. $$R_T = \frac{200 \times 10^8}{128}$$

$$R_T \approx 1.5 \times 10^8 \text{ ohms}$$

10. Therefore, the comb pattern specimen has a MIL-P-55110 equivalent value of 1.5 x 10^8 ohms. Any resistance value less than this during testing was a failure.

TABLE IV

FORMULA FOR LINEAR REGRESSION LINES OF RESISTANCE VS TIME AND ANALYSIS OF LINE SLOPES

72 HOUR DELAY BEFORE FLUX REMOVAL

CONDITIONS	"A" FLUX	"B" FLUX	"C" FLUX
0 Volts Electrical Stress, Conformally Coated	log R = -0.222T+1.7	log R = -0.00839T+0.3202	log R = -0.0703T+1.231
100 Volts Electrical Stress, Conformally Coated	log R = -0.0776T+0.745	log R = -0.505T+3.112	log R = -0.203T+1.202
0 Volts Electrical Stress, Solder Mask Coated	log R = -0.00505T+0.921	log R = -0.109T+1.547	log R = -0.0203T+0.7057
100 Volts Electrical Stress, Solder Mask Coated	log R = -0.0377T+0.523	log R = -0.229T+1.875	log R = -0.168T+1.160
$\overline{X}$ Slopes	- 0.0856	- 0.213	- 0.115
σ Slopes	0.1828	0.1859	0.07334
$\overline{X} + 3\sigma$	0.1629	0.3448	0.1046
$\overline{X} - 3\sigma$	- 0.3341	- 0.7705	- 0.3354
Trend of Slopes Is	Negative	Negative	Negative

TABLE V

FORMULA FOR LINEAR REGRESSION LINES OF RESISTANCE VS TIME AND ANALYSIS OF LINE SLOPES

168 HOUR DELAY BEFORE FLUX REMOVAL

CONDITIONS	"A" FLUX	"B" FLUX	"C" FLUX
0 Volts Electrical Stress, Conformally Coated	log R = -0.0309T+0.3834	log R = -0.0229T=.0399	log R = -0.0659T+0.9007
100 Volts Electrical Stress, Conformally Coated	log R = -0.0534T+0.2055	log R = -.0833T+0.7896	log R = -0.0254T+.2768
0 Volts Electrical Stress, Solder Mask Coated	log R = -0.0796T+1.838	log R = -.0286T+0.425	log R = 0.0323T+.3096
100 Volts Electrical Stress, Solder Mask Coated	log R = -0.0346T+0.5373	log R = -.0286T+0.5196	log R = -0.264T+1.273
$\overline{X}$ Slopes	- 0.0496	- 0.04085	- 0.0808
σ Slopes	0.01929	0.02462	0.1114
$\overline{X} + 3\sigma$	0.008259	0.03301	0.2535
$\overline{X} - 3\sigma$	- 0.1075	- 0.1147	- 0.4149
Trend Of Slopes Is	Negative	Negative	Negative

TABLE VI

FORMULA FOR LINEAR REGRESSION LINES OF RESISTANCE VS TIME AND ANALYSIS OF LINE SLOPES IN PLANT, WAVE SOLDERED, 1 MINUTE DELAY BEFORE FLUX REMOVAL

CONDITIONS	"A" FLUX	"B" FLUX	"C" FLUX
0 Volts Electrical Stress, Conformally Coated	log R = -.0538T+0.567	log R = 0.0547T-0.221	log R = -0.00838T+0.609
100 Volts Electrical Stress, Conformally Coated	log R = -0.0498T+0.755	log R = 0.112T-0.4649	log R = 0.0488T-2.694
0 Volts Electrical Stress, Solder Mask Coated	log R = -0.0116T+0.2076	log R = 0.055T-0.0574	log R = 0.0342T+0.1962
100 Volts Electrical Stress, Solder Mask Coated	log R = 0.0805T+0.5388	log R = 0.0588T-0.898	log R = 0.0904T+0.454
$\overline{X}$ Slopes	-.008675	0.07013	0.04126
σ Slopes	.0546	0.02423	0.0353
$\overline{X} + 3\sigma$	.1535	0.1428	0.1472
$\overline{X} - 3\sigma$	-.1708	- 0.002566	- 0.06466
Trend of Slopes Is	Negative	Positive	Positive

TABLE VII

MIL-P-28809 IONIC CONTAMINANTS TEST

CLEANING DELAY	"A" FLUX RESISTIVITY, OHM-CM X 10^6	"B" FLUX RESISTIVITY, OHM-CM X 10^6	"C" FLUX RESISTIVITY, OHM-CM X 10^6	BEGINNING RESISTIVITY OF WASH SOLUTION
72 Hour				
Specimen 1	10.4	4.3	4.4	
Specimen 2	15.7	3.7	4.6	29 X 10^6 ohm-cm
168 Hour				
Specimen 1	8.8	2.0	2.0	
Specimen 2	9.7	1.0	2.05	
Specimen 3	10.0	1.02	2.0	37 X 10^6 ohm-cm
1 Minute In Plant Wave Solder & Clean				
Specimen 1	7.0	6.2	5.2	23 X 10^6 ohm-cm

APPLICATION		REVISIONS			
NEXT ASSY	USED ON	LTR	DESCRIPTION	DATE	APPROVED

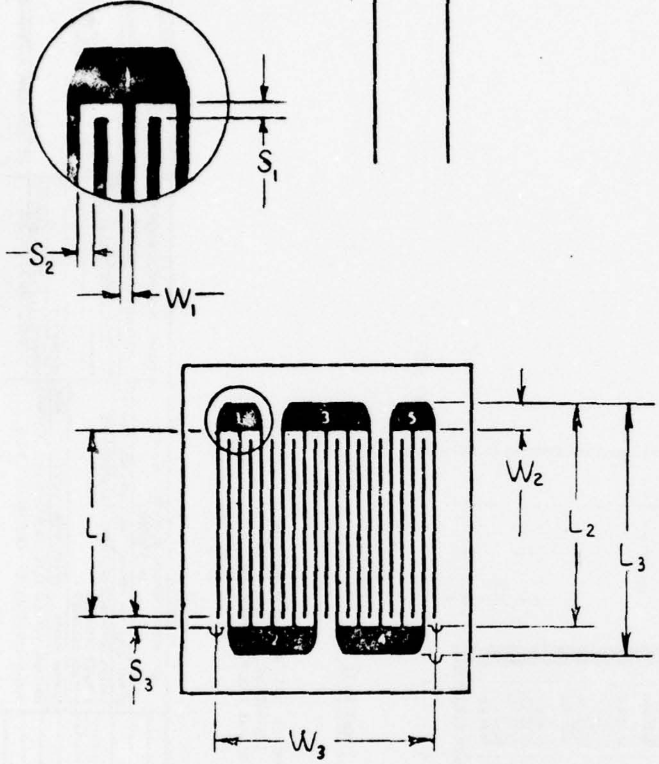


TABLE		
CODE	DIM.	TOL.
L_1	1.250	+.000 -.004
L_2	1.550	+.000 -.004
L_3	1.750	+.000 -.004
S_1	.050	+.004 -.000
S_2	.050	+.004 -.000
S_3	.050	+.004 -.000
W_1	.025	+.000 -.004
W_2	.200	+.000 -.004
W_3	1.525	+.000 -.004

REV STATUS OF SHEETS	REV																					
	SHEET	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

INTERPRET DRAWING IN ACCORDANCE WITH MIL-STD-100

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NAVAL AVIONICS FACILITY
INDIANAPOLIS, IND. 46218

PROJ ENGR	W. T. Holson	5-2-78
ENGINEER		
CHECKED		
PREPARED	J. L. Waste	4-06-78

DEPARTMENT OF THE NAVY
NAVAL SYSTEMS COMMAND
WASHINGTON, D.C. 20360

COMB SPECIMEN

SIZE	CODE IDENT NO.	DRAWING NO.
A		AV-22107
SCALE 1 : 1		SHEET 1 OF 1

MATL ENGR

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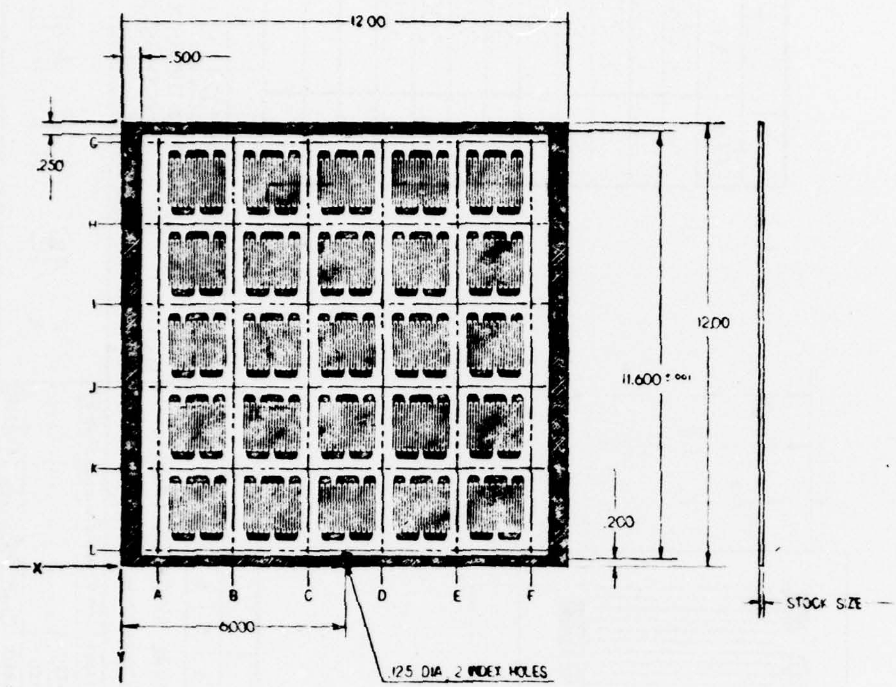

NOTES:

1- THIS PRODUCTION MASTER HAS BEEN DESIGNED FOR FABRICATION BY THE SUBTRACTIVE PROCESS, FROM BASE MATERIAL CLAD WITH 1oz / SQ FT COPPER FOIL.

INDEX HOLE LOCATIONS		
HOLE #	X	Y
1	6.000	0.200
2	6.000	11.800

CUT OFF ℄ COORDINATES		
℄	X	Y
A	1.000	
B	3.000	
C	5.000	
D	7.000	
E	9.000	
F	11.000	
G		11.625
H		9.375
I		7.125
J		4.875
K		2.625
L		0.375

REV STATUS OF SHEETS	REV					
	SHEET	1	2	3	4	5

REVISIONS				
ZONE	LTR	DESCRIPTION	DATE	APPROVED

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2 PLACE DECIMALS ±

REMOVE BURRS BREAK SHARP EDGES MAX

MATERIAL COPPER CLAD GLASS EPOXY LAMINATE
MIL-P-13949, FL-GF-.062-C-1/1-B T B

NEXT ASSY | USED ON
APPLICATION

NAVAL AVIONICS FACILITY,
INDIANAPOLIS, IND 46218

PROJ ENGR 5-15-79
ENGINEER
CHECKED
PREPARED 4-0-78
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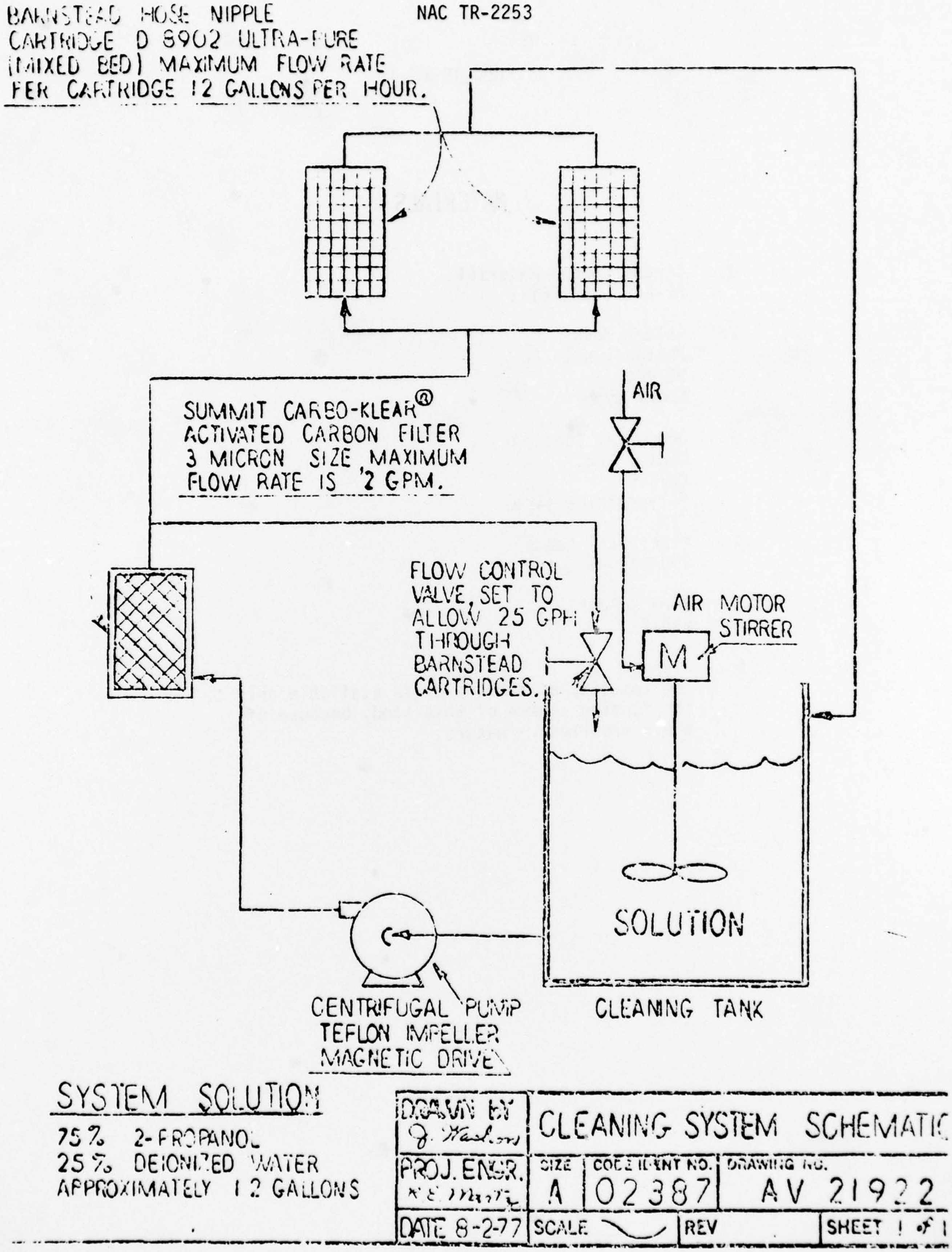
DEPARTMENT OF THE NAVY
WASHINGTON, D C

COMB SPECIMEN (AV22107)

SIZE C | CODE IDENT NO | DRAWING NO AV 22109
SCALE 1:1 | SHEET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CLEANING SYSTEM SCHEMATIC
SIZE A
CODE IDENT NO. 02387
DRAWING NO. AV 21922
DATE 8-2-77
SCALE
REV
SHEET 1 of 1

MATERIALS

1. Circuit Board Material
   FL-GF, .062, C1/1

2. Solder Mask
   Photocircuits Co.
   PC-401
   Epoxy type

3. Conformal Coating
   Conap, Inc.
   CE-1155
   Polyurethane type

4. Electrical Leads
   200AS100-18 wire

5. Wire Solder
   WRP-2

6. Fluxes
   The identity of the fluxes is available only to the funding source of this study because of their proprietary nature.

EQUIPMENT

1. Temperature and Humidity Chamber
   Blue M Co.
   Model FR-256BP

2. Power Supply
   Lambda Co.
   Model LP-534-FM

3. Megohm Bridge
   General Radio Co.
   Model 1644-A

4. Vapor Cleaner
   Acra Electric Corp.
   Spee Degreaser Model D-3

5. Infra-Red Solder Fusing Machine
   Research, Inc.
   Model 4384

6. Wave Soldering System
   Plant fabricated using equipment
   from the following companies:

   Hollis Engineering Inc.
   Electrovert Co.
   Branson Equipment Co.

7. MIL-P-28809 Apparatus as described
   in Naval Avionics Center Materials
   Research Report 3-78

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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10. AVAILABILITY/LIMITATION NOTICES APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED	
11. SUPPLEMENTARY NOTES (12) 58p.	12. SPONSORING MILITARY ACTIVITY RADC

13. ABSTRACT

This study identified the corrosive effects of Type RA fluxes and flux residues on printed wiring boards subjected to electrical stress in a humid environment at elevated temperature. The effect of varying delay times between soldering and cleaning of flux residues was also studied and the protective value of solder resist and conformal coating was evaluated.

DD FORM 1 JAN 64 1473

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
RA Fluxes Printed Circut Boards Corrosion Testing						

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713	1
714	2
900	1

Naval Avionics Center (NAC Report
TR-2253)
Deleterious Effect of MIL-F-14256, Type RA Fluxes on Printed Wiring Boards,by David O.Pond, 31 Jan 1979
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This study identified the corrosive effects of Type RA Fluxes & flux residues on printed wiring boards subjected to electrical stress in a humid environment at elevated temperature.The effect of varying delay times between soldering & cleaning of flux residues was also studied & the protective value of solder resist & conformal coating was evaluated.

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